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## **Of bikes and men**

### **Innovation patterns and strategic entrepreneurship in the human-powered vehicle sector**

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## **Abstract**

Scholars in the field of strategic entrepreneurship emphasize how resource availability and allocation may explain a firm's success. The sooner resources are secured and legitimacy gained the higher the chances for a successful entrepreneurial process will be. However, how this entrepreneurial process evolves and how it is shaped by resource (non-)availability has been largely overlooked. The innovation management literature suggests that the success of innovative process can largely be attributed to a combination of organizational elements such as function expertise, market information and resource allocation. This paper argues that the availability of resources and skills, or the simple lack of them, shape innovation trajectories and strategic actions. In a resource-poor environment, the strategies to develop and commercialise is very much entrepreneurial and emergent, characterized by learning, improvisation and bricolage (i.e. giving value to otherwise worthless resources). In resource-rich environments, the strategies to innovate and to market accentuate high(er) levels of ambition and complexity, hereby relying upon a solid skill and knowledge base. Innovation paths and strategic activities can also be shaped by the chosen organizational form, whether the product development and commercialization is administered through a stand-alone firm, or through a strategic network involving several players. On the basis of an analysis of four case studies in the human powered vehicle sector, we show how the chosen organizational form, together with the initial (non-)availability and the use of resources, shape particular innovation paths and a firm's strategic actions.

## **Introduction**

The history of the Segway Human Transporter is a fascinating account of product innovation and strategic entrepreneurship. When following its evolution from the inspirational to the developmental stages in the early 1990s into the final market introduction in 2002 (Kemper, 2003), one can see how a small and sometimes cash-poor product design company (dominated by one inventor/entrepreneur) came up with the original idea, the markets to be targeted and mobilized most of the resources needed for the Segway's commercialization. The Segway case involves the name, fame and skills of the visionary engineer and serial entrepreneur Dean Kamen; he is the founder of AutoSyringe (which was sold in 1982 to Baxter Healthcare for approximately \$30m); Teletrol, a stand-alone climate controls company established in the early 1980s; and the innovative design company DEKA (derived from the first two initials of Dean Kamen), established in 1982. In one of his projects Dean Kamen, and his core people at DEKA, looked into redesigning wheelchairs on the basis of a self-balancing mobility device (see picture 1a). This extraordinary machine, initially called Fred Upstairs (named after the dancer/actor Fred Astaire) but later renamed as the iBOT, enables users to climb stairs and curbs and master sandy surfaces. Kamen sold the concept for the revolutionary wheelchair to Johnson & Johnson and retained the patent rights to all non-medical applications of his dynamic stabilisation technology. Subsequently, elaborating on the notions of the self-

balancing wheelchair machine and seeing the act of walking as a series of controlled falls, he started to work with his team of designers to develop the world's first self-balancing human transporter, initially called Ginger (named after Fred Astaire's partner Ginger Rogers) (fig. 1b).



Fig. 1a: iBOT



Fig 1b: Segway

After several years of curiosity-driven research and experimentation on Ginger (the nascent Segway) in the 1990s, Kamen and his team of top engineers not only managed to get a proof of concept and subsequently a prototype, but also they started to look into the impact of this alternative personal transportation system on society. They spotted a receptive market for Ginger as an alternative vehicle replacing walking. Three broad user categories for Ginger were distinguished: pure recreation, fun transportation (tourists, shoppers, golfers), and professional application (by the police, postmen, people in airports and warehouses). Notwithstanding the initial successes in terms developing the product and interest among insiders, two conflicts occasionally manifested themselves: one was the extreme secrecy measures Dean Kamen imposed on his core team and hereby effectively hampering market research and field testing and the other was the reluctance to equity sharing and stock options (instead Kamed preferred a traditional incentive system based on salaries and occasional bonuses).

To prepare a future product launch and market introduction of Ginger Dean Kamen and his team had put together a support network, involving a number of strategic partners who would play an integral role throughout the subsequent development process, were brought on board. A new company was established

to bring Ginger to the market (initially called Acros later renamed as Segway) and key outside suppliers and manufacturers (e.g. BAe for the delivery of gyroscopes), healthcare companies Johnson & Johnson and Baxter, and investors Kleiner Caulfield Perkins Byers, CSFB and a group of business angels would provide the new firm's much needed resources and legitimacy (together the informal and formal investors jointly put up \$90m of funding). The final hurdle the Ginger/Segway team faced before product launch was guaranteed access to the sidewalk. This was not an easy job because depending on the perception by (local) regulators, novel vehicles like the future Ginger/Segway could easily be banned on sidewalks and with usage only limited to bike lanes or playing grounds (like what had happened to (motorized) scooters and skateboarders). In order to prevent prohibitive regulations issued by the Consumer Product Safety Commission and the National Highway Safety Administration Ginger needed to be classified as a consumer product and not as a vehicle. Due to an intense lobbying campaign the Ginger team eventually convinced regulators and legislators that Ginger could safely coexist on sidewalks with pedestrians.

Although the much-hyped Segway may not yet reached its full potential yet (at one time the firm was valued in the range of \$500-600million) and sales are still lagging far behind the expectations just before the official product launch for the consumer market in 2002 (the original plan was to sell 31 million items in the first ten to fifteen years; Kemper, 2003), it is a highly uncertain whether Dean Kamen and his people will succeed in building a sustainable international transportation business from scratch. The one product company has now entered a new phase in its development, namely building up a sustainable business with an appropriate distribution and manufacturing system in place, run by a qualified and capable management team.

The Segway/DEKA case allows us to investigate the particular innovation trajectories pursued, the problems the designers and investors found on their way, and the entrepreneurial and strategic processes the new venture unfolded from the start. Elaborating on this, our paper seeks to combine two streams of literature in the domain of organization and management, namely strategic entrepreneurship and innovation management and apply them in the biking industry and the design of alternative human transportation technologies. Strategic entrepreneurship has been positioned by Hitt et alia (2001, 2002) and Ireland et alia (2001, 2003) as integrating the opportunity seeking perspectives from the field of entrepreneurship and the advantage seeking approaches as manifested by strategic management in order to strive for success and create wealth. Scholars in this field emphasize how resource availability and allocation may explain entrepreneurial success. The sooner resources are secured and legitimacy gained the higher the chances to a successful entrepreneurial process (Garnsey, 1998). However, how the entrepreneurial process evolves and how it is shaped by resource availability has been largely overlooked.

The innovation management literature suggests that the success of innovative process is largely attributed to a combination of organizational elements such as function expertise, market information and resource allocation (Montoya-Weiss & Calantone, 1994). How the process, through which these organizational elements are built, influences the innovation trajectory is an emerging topic and needs more scholarly attention. Although design and product development in the bike industry has been studied (e.g. the mountain bike by Rosen (1993) and Luethje et alia (2005) and the safety bicycle by Pinch & Bijker (1984)), like the innovation and marketing strategies over time, pursued by entrepreneurs and manufacturing companies (like Schwinn and Giant among others, e.g. Crown & Coleman, 1996), few scholars have looked into new creative combinations, such as the Segway and other other human powered (and electric) vehicles (HPEV) for short distance. Some of those new transportation technologies, designed to replace traditional bikes, as recently being developed in Europe, will be introduced and discussed in the paper. Furthermore, the paper makes seeks to compare systematically those alternatives to the regular bikes in terms of the evolution of the product, the people and the organizations commercializing them over time.

In our study in the field of aligning innovation management with strategic entrepreneurship in the domain of developing new human transport technologies, the Segway/DEKA case represents an ambitious and visionary project with a munificent resource base from the start and conceived and eventual run by an integrated firm (DEKA/Segway) as the dominant organizational form. In looking at innovation trajectories of new products, services and concepts across several industries and analysing with a given resource base from the start (Berchicci, 2005; Garud & Karnoe, 2003), one can derive that there are alternative product/market/organization combinations available than the breakthrough/mass market/integrated hierarchy configuration, as seen in the Segway/DEKA case. For instance, the organizational form shaping the innovation can also include a strategic network involving several firms and institutions with plenty of resources, as was the case with the development of the Mitka in the Netherlands, or a professional-industrial community of heterogeneous technology hobbyists, associations and 'lifestyle firms' with limited resources, as for instance with the development of the mountain bike in North California. Besides in terms of resource availability, innovation trajectories can also be distinguished on the basis of the chosen organizational form, namely whether the product (re)-design is administered through an entrepreneurial stand-alone firm, such as in the case of the Quest bicycle (with limited resources) or through the electric vehicle SAM (with ample resources).

This paper argues that the availability of resources and skills (in terms of their quality and quantity) or the simple lack of it, and the initial organizational form,

and goal-orientation/ambition level, shape particular innovation trajectories and entrepreneurial strategies. One could expect that in resource-poor environments, the strategy to design, develop and commercialise is very much entrepreneurial and emergent, characterized by learning, improvisation and bricolage (making do with what is at hand, i.e. giving value to otherwise worthless resources) (Baker & Nelson, 2005). In resource-rich environments and for organizations equipped with a solid and legitimate skill and knowledge base, the strategies to innovate and to market often include ambitious yet complex technical solutions. Also the locus of innovative activity can be within an integrated firm with in-house skills, competencies and assets (i.e. the corporate hierarchy being the discretionary authority), or alternatively, a strategic network involving several heterogeneous players matching resources and capabilities, and a shared and collaborative regime.

In this paper we look into the strategic actions of a small number of entrepreneurial ventures, firms and groups and the internal research and development processes of four different innovative human powered and electric vehicles (HPEV) for short distance, selected on the basis of a 2x2 matrix, namely the availability of resources (poor-rich) and the chosen organizational form (an independent stand-alone organization or a strategic network) involving a group of players. We will show how the availability and use of resources and how the initial organizational form instigating product development and entrepreneurial process shape particular innovation trajectories and strategic outcomes. In short, our research question can be formulated as: To what extent resource availability & mobilization explain different processes of innovation and entrepreneurial success in the European HPEV industry. The paper kicks off with an overview of the two theoretical perspectives, namely strategic entrepreneurship and innovation management, subsequently followed by the introduction of a framework in which initial resources conditions and the chosen organizational form are juxtaposed. After a brief methodology section, the four case studies will be reported and compared in terms of the initial resource configuration and the chosen organizational form. On the basis of the literature review and some of the key empirical findings from the case studies, conclusions will be drawn and propositions formulated.

## **Two perspectives: innovation management & strategic entrepreneurship**

### *the Innovation Management perspective*

From the innovation management perspective, whether in established firms or in startups, managers or entrepreneurs need to allocate sufficient resources to achieve the objectives of the innovation process in a project. The innovation process consists of a set of activities that are linked to one another through

feedback loops. The process is often visualized as a chain or steps starting with the perception of market opportunity or a problem or a need, which is followed by the research, the analytical design of a new product or process and testing, redesign and production and commercialization (e.g. Kline & Rosenberg, 1986; Rogers, 1995).

From a resource-view of the firm perspective, the organization is seen as a collection of resources (Wernerfelt, 1984). Resources that enable the organization to develop new products include R&D expertise, knowledge of customer needs and competitive situations, production facilities, and so forth. The synergy of a project with an organization refers to how well the internally-available resources fit the requirements for the new product project, that is the extent to which the new product fits with the organization's resources and capabilities (Danneels & Kleinschmidt, 2001). Moreover, product innovation requires the organization to have competences relating to technology (enabling the firm to make the product) and relating to purchasing (enabling the firm to serve certain customers). By undertaking an incremental innovation process the organization can exploit internal resources and rely on existing competencies of the technology and the market. A new product development that requires different technical and business skills is seen as a radical undertaking because such projects mean greater challenges and risks for the firm (Green & Welsh, 2003; Schmidt & Calantone, 1998; Schoonhoven, Eisenhardt, & Lyman, 1990). Projects with more radical characteristics require larger resource commitments (Green et al., 2003), longer time-to-market (Schoonhoven et al., 1990), different organizational units (Christensen & Bower, 1996) and different capabilities (Green, Gavin, & Aiman-Smith, 1995).

From this perspective, scholars warn that inadequate resources in technical (Calantone & Dibenedetto, 1988) and market (Cooper & Kleinschmidt, 1995) activities and execution (Montoya-Weiss et al., 1994) may endanger the innovation project. Based on several case studies, Cooper argues that the best performing businesses had the greatest excess resource for innovation projects (Cooper & Edgett, 2003). Even to succeed on one's own without support needs adequate resources to guarantee a set of potential innovative projects (Cooper, 1984). The availability of resources allows entrepreneurs and managers to plan the activities for the innovation project, and for startups the earlier the resources are allocated the higher the chances for a successful venture (Garnsey, 1998).

The excess resource does not prevent managers to avoid risks in managing innovation process. With greater resource availability, managers could become overly optimistic and implement inadequate strategies or escalate their commitments resulting in poor performance. They may pursue an innovation process that overemphasizes superior solutions and reflect internal beliefs rather than external feedback (Berchicci, 2005). Garud and Karnoe (2003) called this

approach '*breakthrough*' which '*evokes an image of actors attempting to generate dramatic outcomes*' (Garud et al., 2003: 279). It emphasizes the act of doing something new through leap-frog advancements. Studying the wind turbine technology development process in the US and in Denmark, Garud and Karnoe (2003) found that the actors in the U.S. pursued an approach that attempted to generate breakthroughs designing a high-tech, light-weight and high-speed turbine. The overconfidence on theoretical frames prevented these actors from truly understanding the complexities of wind turbines. These authors did not analyze how the type of resources may influence the choice of the innovation approach.

On the contrary, the Danish actors in Garud & Karnoe's study took a *bricolage* approach scaling up from a heavy-weight, low-speed simplistic design to a well-functioned and sophisticated design, one of the most successful designs worldwide. With actors improvising and adapting, the emergent path was transformed to higher functionalities (Brown & Eisenhardt, 1997; Garud et al., 2003). The bricolage process connotes resourcefulness and adaptiveness among the actors involved in the development process. It is also a "baby step" approach, a process of moving ahead on the basis of small feedback signals. In practice, the practical experimentation coupled with thoughtful modifications allows the new system to emerge and be gradually shaped. It is important to emphasize that Garud's definition of bricolage is different from what bricolage was originally meant. The evolution of the bricolage concept requires an attentive elucidation. Traditionally anthropologists such as Levi-Strauss (1966) defined bricolage as the process of making with current resources, creating new forms from tools and materials at hand (Baker, Miner, & Eesley, 2003). For example, one may decide to build necklaces with only materials left on the seashore. From this perspective, the bricolage approach would create only incremental, 'just good enough' products rather than superior products. Recently, scholars see the bricolage as a process that denotes a sequence of innovations, trial and error experimentation, fast development with resources at hand (Garud & Karnoe, 2001). From this perspective, the bricolage approach may create superior products through incremental steps.

#### *the Strategic Entrepreneurship perspective*

In their definition of entrepreneurship Shane & Venkatamaran (2000: 218) emphasize that it is a 'nexus' that involves entrepreneurial individuals seizing lucrative opportunities: 'the field involves the study of *sources* of opportunities; the *processes* of discovery, evaluation, and exploitation of opportunities; and the set of *individuals* who discover, evaluate, and exploit them.' By actively linking the generation of ideas, concepts and products and the spotting and seizing of opportunities, these 'entrepreneurs' make a positive contribution to the innovativeness, economic activities and dynamics of a country. There is another

ingredient we need to address in our discussion of the building blocks of entrepreneurship, and that is the new enterprise that is created by the new entrepreneur to exploit the idea or opportunity commercially and to market the innovation. In entrepreneurship research we should try to investigate the role new ventures play in furthering economic progress: entrepreneurs establish new organizations, non-entrepreneurs do not (Gartner 1985; Low & Macmillan, 1988). It is important to emphasize that in the process of identifying and pursuing opportunities, entrepreneurial individuals - either acting on their own or inside an organization - have limited resources at their disposal and face major uncertainties and risks (in terms of demand, competition, supply, prices and the development of skills) (Stevenson et al., 2000). In the initial stages entrepreneurs often have to do more with less and use what abilities and resources they have at their disposal, which are often the ones that are hidden, overlooked or neglected by others. In other words, most firms set out with a minimum of capital and a maximum of ingenuity and improvisation.

Aware that attaining their goals and ambitions requires considerably greater resources than the ones to which they currently have access, entrepreneurs have to be creative in how they use and acquire their resources. In this 'bootstrapping' process (Bhidé, 1992; Winborg & Landstrom, 2000; Harrison et al, 2004) where access and acquisition is sought to external and non-owned resources in creative ways, starting entrepreneurs can fall back on several tactics, such as substituting social capital for financial capital, working from home, buying used equipment or renting equipment (instead of buying new), generating word-of-mouth marketing, not being paid for shorter/longer periods, deliberately delaying payment to suppliers, exploiting cheap and flexible labour, and turning customers into sales personnel. As Starr & MacMillan (1990) put it, they have to be parsimonious with their assets: buying only what is needed and using the rest without actually owning it, obtaining professional advice through friendship or the promise of future business, raising funds from family, bringing in cash flows before allowing major expenditures. In this phase entrepreneurs are 'hustlers' (Bhidé, 1986): they act before they analyze, or act and analyze simultaneously. Often the line between research and selling becomes blurred, and entrepreneurs will try to sell their product or service while they are officially looking for advice, information and initial commitment.

New entrepreneurs start out with a limited amount of knowledge and pursue modest strategies, with their initial successes depending on their ability to exploit unexpected opportunities. Their success depends on their ability to transform and upscale themselves as they grow in order to benefit from their increased size, allowing them to take on more capital-intensive projects with more predictable outcomes (Bhidé, 2000). On the basis of these dynamic skills and modest and parsimonious planning, entrepreneurs learn and become more ambitious. Initially, stakeholders have a low level of commitment, but as time

goes by, they may increase their commitment as the new entrepreneur proves to be a trusted partner. While most entrepreneurs start their company on a shoestring with initially limited ambitions and resources, and a niche market orientation, there is a small group of new ventures that operate in a diverse setting and face different initial conditions (like Dean Kamen's Segway): the so-called venture capital/VC-backed and revolutionary start-ups. These young and growth-oriented companies have either unusual endowments (e.g. innovative concepts, exceptional entrepreneurial talent) attracting significant funds from investors (i.e. for vc-backed start-ups) or truly extra-ordinary endowments (e.g. a blockbuster idea, significant personal wealth) and otherwise exceptional capacities to raise capital (i.e. for revolutionary ventures) (Bhide, 2000).

Some scholars in the field of management and organization (e.g. Hitt et alia 2001 & 2002; Ireland et.al 2001 & 2003) have sought to combine entrepreneurship theory with strategic management. One side of the coin of Strategic Entrepreneurship (SE) is the focus on the entrepreneurial actions of new and agile firms that are identifying and seeking to exploit opportunities for new business and future growth rivals have not seized yet or altogether commercialized. The other side of the SE coin includes the strategic actions of larger and more mature companies, having survived the critical stages and liabilities of start-up and growth, aiming now at developing and exploiting competitive advantages in order to create wealth. Elaborating on those two assumptions (i.e. sides of the SE coin), strategic entrepreneurship can then be conceived of as the integration of an entrepreneurial perspective with an eye on opportunity seeking activities by dynamic firms exploring and exploiting new business, and a strategic perspective with a focus on advantage-seeking actions to build a superior company and to create wealth.

Entrepreneurship zooms in on bringing together distinctive stocks of resources to exploit opportunities and on leveraging them through new venture creation. Strategic management provides a larger context for the activities of these dynamic and entrepreneurial firms for their next steps in their development and ultimate wealth creation, by pursuing ambitious innovation, growth and/or internationalization strategies and investing in external networks, organizational learning and/or leadership. By looking further into these varying patterns entrepreneurial actions and corporate decisions, Mintzberg & Waters (1985) have made a useful distinction between deliberate or planned strategies, i.e. intended, realized, and often imposed top-down, and emergent strategies, i.e. realised despite or in the absence of explicit intentions due to bottom-up initiatives and activities trigger by experimentation and trial and error learning. One would expect that the opportunity-seeking entrepreneurial firm would rely more on emergent strategies and an advantage-seeking (more) mature firm would rely substantially on deliberate planning.

## **Drawing up a framework: Juxtaposing resource configurations and organizational forms**

### *Initial resources configuration: availability and constraints*

Despite of its importance, the role of resources and their influence on entrepreneurial venture has been poorly discussed in the literature. Here we refer on the specific literature on the relationship between the type of resources and innovation and performance. Scholars often refer to the term "slack" to identify utilizable resources that can be deployed for any organizational goals. Usually, entrepreneurial firms do not have slack resources at the start of their venture, but they may have resource availability in excess of resource demand for the venture, condition defined here as resource-rich. Two perspectives have looked at resource-poor vs resource-rich condition, we discuss their relevance concerning the role of resources in innovation. Behavioral theorists argue that excess resources provide opportunities for innovation and enhances experimentation (Cyert & March, 1963). Resource availability allows firms to cope with environmental shock (Thompson, 1967) and to compete more effectively (March & Heath, 1994). On the contrary, resource constraints theorists argue that firms with fewer resources are likely to use them more efficiently (Baker et al., 2005) while firms with excessive resources are operating suboptimally (Leibenstein, 1966). Empirical evidences gives a blurred picture.

Slack resource fosters experimentation but decreases discipline in doing innovation (Nohria & Gulati, 1996). Examining 264 functional departments of two large corporations, they suggest that exists an inversed U-shaped relationship between slack and innovation (Nohria et al., 1996). Concerning startups, new firms with limited resources develop moderately new products and ship them faster and survive longer than other startups pursuing very new products (Schoonhoven et al., 1990). Baker and Nelson, taking a constructive perspective, found that entrepreneurs may refuse the idea of resource scarcity as limitations, creating something from what other may consider nothing (Baker et al., 2005).

On the other hand, excess resources may influence positively the adoption of technological innovation (Nystrom, Ramamurthy, & Wilson, 2002) and allow product developers to work on their own projects and applying loose performance standards for new projects (Jelinek & Schoonhoven, 1993). Others have focused on managerial discretion in using excess resources. Low level of discretion (e.g. fixed assets) provides less flexibility in using resources than high level of managerial discretion (e.g. cash). In a private held firm setting, George found a concave relationship between performance and low-level discretion and a linear positive one between performance and high-level discretion (George, 2005).

The literature on rich versus poor resources focuses on the relationship between the quality and type of resources and performance but it is adamant in how innovation is processed. This paper attempts to fill this gap. One exception is the Baker and Nelson's work in which entrepreneurs adopt a bricolage approach, a concept coined by Levi Strauss indicating the creation of something with resources at hand and recombination of resources for new purposes (Lévi-Strauss, 1966). The bricolage is an important concept to explain the role of resource scarcity in innovation process, as explained in the next section.

*The chosen organizational form: corporate hierarchy or strategic network*

What is the better way to pursue innovation is still matter of debate. Here we highlight 3 discrete forms of organization: incumbents, de novo firms and strategic networks. Conventional wisdom suggests that young and small firms have a greater advantage in innovation (e.g. Ács & Audretsch, 1990). In general those firms possess capabilities as niche-filling and flexibility, seeking out protected market niches that are too small for larger organizations (e.g. Chen & Hambrick, 1995). Moreover, these organizations are also seen as being quicker than established organizations due to structural simplicity, streamlined operations, lack of structural inertia, faster decision-making process and targeted innovation (e.g. Dean, Brown, & Bamford, 1998). The result is a quicker response to the dynamics of industry environments. These arguments seem to be supported by many recent studies which tend to find that small firms have introduced a proportion of innovations larger than their share of employment. This finding has frequently been interpreted as showing that small firms are more innovative than large firms, or more efficient innovators, achieving greater outputs per unit of R&D input (Acs & Audretsch, 1991; Cohen, 1995).

In contrast, there are arguments in favor of established organizations in relation to innovation. The advantages of established organizations, as we previously discussed, are the market power over customers and suppliers, the exploitation of patents and scale economies in R&D, accumulation of technological knowledge and capabilities, competitive strengths in terms of available resources, managerial knowledge, and ability to handle uncertainty (e.g. Aldrich & Auster, 1986; Cohen, 1995). Furthermore, established organizations often have external relationships, contacts and reputations that expose them to new competitive tools and technologies.

Just as small and established organizations differ in the advantages they have, they also differ in their weaknesses. While startups may be more innovative, they frequently have trouble bringing innovations to the market in a successful way. On the contrary, while established organizations have more trouble innovating they have greater success bringing innovations to the market (Abernathy &

Utterback, 1978). The established organizations are believed to be constrained by organizational rigidities, structural inertia, technological myopia and poor incentives in pursuing radical innovations. On the contrary, young and small firms, because of liabilities of newness and smallness, are subject to lack of market recognition, weak financial positions and lack of internal structure. They will be more likely to succeed when entering industry environments in which speed, flexibility and niche are rewarded or when pursuing radical innovation in a fragmented industry.

It seems that an answer to the question of what is the best organizational form is unlikely to be exhaustive, because, as Aldrich and Auster (1986: 168) said, 'the obstacles faced by new, small organizations can be easily overcome by incumbents, whereas the constraints faced by larger and more established organizations can often be easily overcome by new and small ones'. The network of various organizations, being an intermediate form of organization (Powell, 1990) may provide a more conducive environment for product innovation or a new business creation (Van de Ven, Polley, Garud, & Venkataraman, 1999). In theory, it can overcome the liabilities of newness, smallness, bigness and aging. However, in practice problems in managing joint ventures largely stem from having more than one parent organization. Thus the problems of communication and conflicts in large organizations are likely to increase in networks. Moreover, sovereign conflict, antitrust, intellectual property and appropriability conflicts and losses of autonomy and control are liabilities of "double parenting and conflict" (Van de Ven et al., 1999).

### *Synthesis*

This paper argues that the availability of resources and skills (in terms of their quality and quantity) or the simple lack of it, and the initial organizational form, and goal-orientation/ambition level, shape particular innovation trajectories and entrepreneurial strategies. One could expect that in resource-poor environments, the strategy to design, develop and commercialise is very much entrepreneurial and emergent, characterized by learning, improvisation and bricolage (making do with what is at hand, i.e. giving value to otherwise worthless resources) (Baker et al., 2005). In resource-rich environments and for organizations equipped with a solid and legitimate skill and knowledge base, on the other hand, the strategies to innovate and to market often include ambitious yet complex technical solutions. Also the locus of innovative activity can be within an integrated firm with in-house skills, competencies and assets (i.e. the corporate hierarchy being the discretionary authority), or alternatively, a strategic network involving several heterogeneous players matching resources and capabilities, and a shared and collaborative regime.

In the subsequent sections we will look into the strategic actions of a small number of entrepreneurial ventures, firms and groups and the internal research and development processes of four different innovative human powered and electric vehicles (HPEV) for short distance, selected on the basis of a 2x2 matrix (see fig.2), namely the availability of resources (poor-rich) and the chosen organizational form (an independent stand-alone organization or a strategic network) involving a group of players. We will show how the availability and use of resources and how the initial organizational form instigating product development and entrepreneurial process shape particular innovation trajectories and strategic outcomes. In short, our research question can be formulated as: To what extent resource availability & mobilization explain different processes of innovation and entrepreneurial success in the European HPEV industry.

Figure 2	Organizational form		
Resource availability & mobilisation		Start-up	Strategic Network
	Rich	SAM	Mitka
	Poor	Quest	Mountain bike

### Method

The lack of sufficient understanding of how initial resource configurations and chosen organizational forms in the field of human powered vehicles requires a qualitative empirical line of enquiry. This type of study is well-suited for *exploring and discovering* new substantive areas about which little is known (Strauss & Corbin, 1999). This research project utilizes the case study research strategy. The underlying rationale is based on some key features well-suited for the purpose of this research study. First, the case study method is well-suited for studying the overall picture of the research object as a whole. It allows for the in-depth identification of a variety of contextual factors when the phenomenon under study is dependent on a large number of factors (Verschuren & Doorewaard, 1999). Second, it is an appropriate strategy for enriching or extending theory, yet also accommodating existing theories through an iterative process (Yin, 1994). Third, compared to other methods, the case study method provides evidence in a situation in which all of the relevant behaviors cannot be manipulated through experimental design. Moreover, it may elucidate and explain a decision or a set of decisions too complex for a survey or experimental

strategies (Yin 1984). Finally, it allows the incorporation of a variety of different sources of evidence, including archival documents and interviews (Yin 1984).

### *Case selection*

Qualitative sampling, unlike quantitative sampling, tends to be purposive rather than random. The choice of informants, episodes and interactions are being driven by a conceptual question, not by concern for “representativeness” (Miles & Huberman, 1994). Sampling in qualitative research is usually not wholly pre-specified, but it evolves once fieldwork begins. Regarding this research study, one of the authors had the opportunity to step into the Mitka project, started in the Netherlands in which the objective was to design and to develop a new three-wheeled human-powered vehicle (Berchicci, 2005). Therefore, the Mitka project was considered an interesting case study for its resource-rich conditions, its level of innovativeness, and project ambition. The other three projects in the short distance mobility sector were chosen to gain an even deeper understanding of the phenomenon under study. The reason was to be able to compare decisions during the innovation process within a similar technical and market environment. Given the limited number of cases that can usually be studied, according to Pettigrew (1990), it makes sense to opt for cases with extreme situations and polar types in which the phenomenon of interest is ‘transparently observable’. The advice of Pettigrew was followed in choosing polar types, however variations in specific settings were restricted.

To restrict variations, the cases need to have a similar *context* and to present a high level of uncertainty in the innovative undertaking. It was felt that on the one hand, the selected cases needed to be a new product development project in the *HPEV sector*, with similar technical characteristics of the Mitka. Specifically, the new venture’s objective needed to be the development and the implementation of a new short distance vehicle. On the other hand, the selected cases were required to be polar types with respect to the *organizational setting* (startup vs network of players) and to *the quantity of resources* (rich vs poor). Beside the Mitka, the SAM, the Quest and the mountain bike were chosen. The Mitka was started by a network of organizations with resource-rich conditions and the mountain bike by a resource-poor community of practice, while the Quest and the SAM were projects started by start-up entrepreneurs. The former with resource constraints, while the latter with plenty of resources. On the other hand, they have similar technical characteristics and function, were designed for the similar market.

Besides being polar types, the two cases present methodological differences. The study of the Mitka case resembles longitudinal research in *real time*, meaning that the researcher lives with an organization over time or carries out periodic interviews (Pettigrew, 1990). In a period of more than two years, real-time data

were gathered through observation, meetings and interviews. On the contrary for the other three cases (mountain bike, SAM and the Quest) real-time data collection over the whole innovation process, although desirable, was not feasible. *Ex post facto* investigations were needed to reconstruct the product development process. Thus *retrospective data collection* was the main source for the other cases study.

### *Data sources*

Case study research privileges qualitative and unstructured ways of gathering data (Verschuren et al., 1999). Except for the mountain bike case (which was written on the basis of secondary sources), a selection of key informants was based on their knowledge of the project and their proximity to the decision-making process. Thus, members of the project team were identified as primary key informants and, adopting a snowball method, additional relevant key informants involved in the projects were interviewed. The interviews were semi-structured and lasted from one hour and half to three hours. Informants were first requested to describe the historical timeline of the project and its main players, and decisions taken during the process. The initial interviews were kept broad in scope in an effort to expose a wide range of motivations, decisions and competences. As the research project progressed and the theory was refined interview questions became more focused in an effort to ascribe more details to the emerging patterns. To build internal validity inconsistencies were probed further (Eisenhardt, 1989).

During the period 2001-2003, one of the authors had the opportunity to participate in the product development of the Mitka project, observing the team at work (Berchicci, 2005). Although these observations were not coded, they were instrumental in shaping initial conceptualizations for the preliminary model. Several discussions and informal conversations occurred with the team members regarding technical development as well as market research. The author's role was active in the project with regard to the market research, in particular the test preparation and implementation. The same author also made interviews with the key stakeholders in the development of the Quest and the SAM. The fourth case study was based on secondary sources, such as books (Crown & Coleman, 1996), the popular press (Berto, 1999), articles (Rosen, 1993, Buenstorf, 2000; Luethje et al., 2005).

In qualitative case study research, corroboration of interviews through archival records is important to validate information (Yin 1984). Therefore, the interview data were supplemented with information from archival documents and press releases. Internal reports, archival information, newspaper and magazine articles were used to confirm the reliability of the interviewees' responses and permitted directed and detailed probing in the interviews. The data collected were the

backbone of every case description. All the sources of evidence were reviewed together; consequently the case description was based on the convergence of information from different sources. The use of different sources enables to crosscheck findings using the method of triangulation, which increases the reliability of the conclusion (Yin, 1994). A detailed written case history and timeline was prepared along with a schematic representation of the main phases and events. The descriptive *time-oriented* display is utilized arranging a series of concrete events by chronological time periods. These periods are based on the categorizations made by Van de Ven et al. (1999)

## **The four cases**

### *The Mitka*

The Mitka is a story of a group of ambitious players attempting to develop a really new product for a new market. The idea to have a new concept of transportation that could combine a number of car and bicycle attributes was a combination of the interests, expectations and opportunities of different organizations, such as the TNO research institute, a bicycle manufacturer, a sportswear manufacturer and a university. The final concept of the Mitka is the result of many ideas brought together by some key actors during the whole process. What is the Mitka? The Mitka is a roofed, three-wheeled human-powered vehicle with an electric engine that doubles human pedaling power. It has a maximum speed of 25-40 km/hour and automatically tilts during steering (Fig. 3). The Mitka concept is based on the assumption that people will use the Mitka instead of the car and thus will use less energy in regular (home-work, shopping, visiting) transportation. The motivation to start such a project was driven by the strong belief that to reduce environmental problems of the current mobility system, new solutions were necessary. The project leader was able to create the conditions for obtaining initial resources and partners. It turned a broad vision of a societal problem into a specific project: a human-powered vehicle.

To understand the technological, economical and ecological potential of a new mobility vehicle, TNO performed a market study in the European Nike headquarters in Hilversum. In March 2000, it was launched through an internet-based questionnaire given to Nike employees. The respondents were asked to "build" on a computer screen, out of individual components, a vehicle that would meet the general set of specifications defined earlier by the Mitka coalition and their own preferences as future Mitka users. One of the central findings from this exercise was the strong users' preference for a two-wheeled vehicle over a three-wheeled version. In May 2000, the coalition decided to develop a three-wheeled Mitka for two reasons. First the three-wheeled concept was considered

more innovative than the two-wheeled one and the reaction of the lead users was considered conservative. The second reason was because it was “better for the natural environment”. The coalition felt that developing two-wheeled version meant likely attracting bikers with unwanted and disastrous consequences from an environmental impact view.



Figure 2: Mitka vehicle (October 2002)

The design team worked on a scale model (1:3), which was presented on September 20, 2000 at the Nike European head office in Hilversum. At the symposium, the Mitka model attracted the curiosity of many people and journalists who reacted very positively to it. The following days, large press coverage described enthusiastically the futuristic vehicle.<sup>1</sup> The enthusiasm was contagious. The coalition was resolute to explore the promising Mitka trajectory. The euphoria boosted the project, which was expected to result in a marketable product in less than 3-years.

This proactive attitude was translated in a new set of objectives for the following phases: the development and test of a vehicle prototype, and later the production of a pre-series of 50-100 vehicles with dedicated services for a new market (Joore, 2000: 7). The main idea for the business plan was to sell an attractive package of ‘sustainable mobility solutions’ to employers of large and medium corporations. The goal was to reach 1% of the bicycle market that means 10.000 units per year. The suggested prize for the Mitka was fixed around 3.000 €. For this phase of the project a total of 350.000 € were secured building on 200.000€ already employed. Between February and March 2001 the coalition was looking for feedback to the Mitka concept. Group discussions and in-depth interviews with Nike employees, who had difficulty envisioning the daily life with the new artifact; according to the experts Luiten, Knot, & Silvester, 2001): ‘*The*

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<sup>1</sup> For example, articles in two national newspapers: the *Algemeen Dagblad* September 21, 2000 and *De Telegraaf*, September 29, 2000.

*three-wheel design was not so much appreciated, mainly because problems were expected concerning the maneuverability, which was, according to them, one of the most important advantages of a bike above the car. Many group-members were quite enthusiastic about the design, but also a relevant part thought it would be 'too new' for them.'*

On the contrary, a public presentation of the Mitka mockup, where the future King of the Netherlands sat on it next to his wife, created great enthusiasm among the team. Marketers affirmed that everything the Princess is displayed with will sell. The general feeling was clearly expressed by the business developer: *'the world stands still without the Mitka'*.<sup>2</sup> Rather than performance criteria, prospects and expectations of the coalition were the main mechanism for project support. The management team let the design team work on the Mitka, adopting a 'wait and see' attitude. The wait and see attitude postponed any reflections, self-assessment and critical evaluation of goals and objectives, allowing the project to proceed without checking any real performance judgments. Moreover, the limited capabilities to understand the technical development reinforced this attitude, which, in October 2001, did not prevent the team to invest 600.000 € to fulfill ambitious objectives. These objectives included having the final Mitka prototype ready, tested and finally produced.

The decision to develop such a brand-new environmentally-friendly vehicle presented both technical challenges for the team and business and market risk for the entire coalition. All the working packages entailed completely new design and development techniques, with very few standard parts. The team had difficulty coordinating their single developments and the whole product architecture. For example, the challenge faced by the team was to build a three-wheeled vehicle where an upright position, that means a high centre of gravity, was combined with the tilting and steering mechanism of the two wheels in front. A couple of problems, however, arose with this configuration, namely stability and maneuverability: the width had to be around 85 cm to have a good maneuverability. However, the width necessary for the tilting/steering mechanism works soon presented a practical problem: vehicles wider than 80 cm are unlikely to pass through doors, as emphasized by the market research.<sup>3</sup> Moreover, concerns about the combination of a high center of gravity and a three-wheeled configuration were expressed by recumbent bike experts and velomobile producers, because at low speeds the tilting effect was dangerously strong and the vehicle might just bend over because of the high centre of gravity. After several parallelogram constructions, the tilting problem still existed and the project team was confident and committed to resolve it.

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<sup>2</sup> The business manager, interviewed on January 23, 2002.

<sup>3</sup> In the Netherlands, bicycles are often stored inside houses whose front-doors are around 80 cm wide.

The unexpected technical problems did not undermine the confidence of the team, despite their limited expertise and knowledge on 3-wheeled configuration as well as roof and power assistance. On the contrary, their commitments locked the design team within the boundaries of the ideal means of transport, allowing them to work also extra hours and sometimes in the weekends. The design team did not challenge the requirements of the Mitka. It was felt that any downgrading from the original design would have negatively affected the sleek appearance and the environmental intrinsic value of the Mitka. Consider some of the technical dilemmas such as the wheel configuration. Intriguingly, it seems that the team opted for the most complex and radical solutions among different technical choices. The intertwined events illustrate the difficulty for the project team to deal with feedback received and their own beliefs. Positive feedbacks were emphasized while negative feedbacks were avoided or completely ignored when not aligned with their own belief. This was a kind of paradox. The decision to start such a project was based on the assumption of combining user need, an ideal mobility concept, with more general societal needs, the preservation of the natural environment. However, the crucial decisions during the process were not influenced by the users' preferences.

Unfortunately, it took 8 more months (May 2002), to be able to ride the first Mitka prototype and 13 months (October 2002) to test the only prototype. Expectations based on e-mails' or meeting announcements of the coming prototype and testing were regularly dashed. One of the effects of the procrastination of the project was the relocation of resources. Resources previously allocated to market research activities were transferred to strictly technical product development activities. During the test in October 2002, the insufficient lighting, poor visibility and poor maneuverability forced the two drivers to drive off-pick hours to avoid other bikes along the path. As one of them said: *'it was fighting all the way home!'* Unsurprisingly, the test and the project was stopped prematurely. After 3 years of product development and about 1.150.000€ invested, the ambitious Mitka project ended with one prototype.

### *The Quest*

The Quest is a velomobile, that is usually understood to be fully or partial faired, human-powered vehicle and almost always three-wheeled for stability (for a recent history of velomobiles, see Walle (2004)). Not to confound with the type of the vehicle, the firm under study is named *Velomobiel* (Dutch translation of velomobile). The company was founded by Allert Jacob and Ymte Sijbrandij in 1999 under the name of *J&S Fietsdiensten* (J&S bicycle service). In 2001 the name changed in *Velomobiel*, to give more visibility, with the arrival of a new partner, Theo van Andel. The company encompasses 3 individuals, Allert Jacob is the designer and developer of the two *Velomobiel's* vehicles, while Ymte

Sijbrandij is the Market developer and Theo van AnDEL is in the assembly line, all of them work on the production line. The Quest (fig. 4) and the Mango are the two Velomobiles produced by Velomobiel. The first project was the Quest introduced to the market in 2000 costing 5672 € while the latter was introduced two years later at 4500 €. The Quest is longer and faster while the Mango is cheaper and has a smaller turning cycle to improve maneuverability.

To fully understand the Quest story, a step back is required stopping the clock somewhere in 1993 when a special event was being prepared. In the occasion of the 365-days-fiets-prize organized by the magazine "Fiets" (translated "Bicycle", magazine printed in The Netherlands) Allert Jacob was asked to be the driver of the *Alleweder*, a semi covered recumbent bike produced by the *Flevobike* Company.<sup>4</sup> Allert Jacob was one of the racing champions of NVHPV (Dutch human-powered vehicle association) and already a client of Flevobike owning one of their recumbent bikes.



Figure 3. The Quest

Alleweder won the competition with Allard as the driver. Thanks to the publicity advertising this event and the press coverage of the event after it took place, the name Alleweder started to spread in the bike world and the Flevobike Company decided to produce it. This decision created the opportunity for Allert Jacob to start new work and be part of a new phase of the Alleweder's development. In 1995, Ymte Sijbrandij started to work at Flevobike as book keeper and shortly afterwards with Allert Jacob he decided to be co-owner of the Flevobike Company. They had numerous ideas and they decided to invest in Flevobike. In the same period, Allert Jacob (after building 200 Alleweder and 400 recumbent bikes) decided to work only 3-4 days a week and invest the remaining time working on his own projects in the workshop, such as two wheelers and a redesign of the Alleweder.

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<sup>4</sup> The Flevobike Company is a small family-owned company founded by Johan Vrielink. Flevobike started to produce and sell recumbent bikes since 1986.

From cutting the aluminum sheets with scissors to machining the suspensions or fixing the derailleur, Allert Jacob built his technical skills and competences learning how to produce and assemble this special vehicle. Besides these competences, the extensive use of the bicycle, both for leisure and for competition purposes, created the conditions for him to identify the strong and weak points of the vehicle and discover new opportunities for improvement. This learning experience and his passion for cycling created the conditions to envision a superior bicycle not yet in the market: a fast, comfortable, light and weather protected human-propelled vehicle. He shortly came up with a short list of product requirements for a new version of the Alleweder, by reducing the weight and maintenance time and improving the aerodynamics. Although he was not a designer, he managed to design from scratch and develop a new C-Alleweder prototype. The search for the fastest, lightest, maintenance-free vehicle influenced his decisions to develop a radical new vehicle characterized by a new monocoque fairing with less air resistance and composed of a lighter material, carbon glass fiber.

To improve the aerodynamics drawings and small models were the tools utilized; however some of the fundamental rules from the Alleweder vehicle, like the driver's position, were kept. "*Rather than planning, it was a process of estimating, assuming and guessing*".<sup>5</sup> The first C-Alleweder (named "C" because of the carbon's element in the body) was finally ready at the end of 1996. The body was carbon and glass-fiber, with no frame inside, only the gears and pedals were made of metal. The chain was inside the fairing, consequently there was no chain maintenance. The new C-Alleweder was indeed faster and lighter than the regular version. These visible improvements did not prevent other problems from emerging. First, it was time consuming. The reason was because of "*the lack of experience in working with glass fiber*".<sup>6</sup> The second drawback was strongly related to the first one, it was very expensive to build one. The design did not take into account the production process because the C-Alleweder was not meant to be sold. Nevertheless, a small scale production process was put in place to address the increasing demand of new clients.

In 1998, C-Alleweder production stopped. Besides the cost and the high production time, the reason to terminate production of vehicles was because the Flevobike founder did not fully support the development of the C-Alleweder. He intended to stop producing recumbent bikes and the Alleweder all together and to focus on R&D only. This decision had a major impact on the relationship amongst the partners. In spring 1999 Allert Jacob and Ymte Sijbrandij left Flevobike Company and founded a new company, J&S, to be able to build a new vehicle with a lower air drag; according to Allert Jacob: "*Because I wanted to ride one, I wanted to have one! This was the first motivation to make it. It was the*

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<sup>5</sup> Interview with Allert Jacob on January 28, 2004.

<sup>6</sup> Ibid.

*same for the C-Alleweder, I made it because I wanted to ride something like that. And we knew, thanks to the experience in Flevobike, it was possible to have a small company and to build and sell special bikes. If we didn't work in Flevobike, probably we would never have started a company. It is not easy to leave a job and start a new one, if you don't know anything about it. But we knew that it could be done, even better.'*<sup>7</sup>

Starting a new company with the ambition to develop a new concept vehicle is not an easy task without financial resources. To cope with that, both of them started to do different jobs; according to Allert Jacobs: *"Ymte became a truck driver for a furniture import-export company but kept his job as book keeper for Flevobike, while I started in my garage a workshop with different machines and tools to machining. I had different assignments, for example I worked for Cab-bike [[www.cab-bike.de](http://www.cab-bike.de)] doing suspensions."*<sup>8</sup> The C-Alleweder was an important lesson for the designer. He realized that the design and the use of new materials for a completely new monocoque fairing cannot be done without thinking about the production and assembly process. To have a vehicle in the market in a short period of time, the design needed to be functional to the production process. The new project was based on the C-Alleweder with potential improvements both in the aerodynamics and in the production process. The main product requirements were higher speed and easy-to-produce.

Before proceeding with the new design, Allert Jacob decided to build new capabilities with regard to fairing shapes to improve the C-Alleweder's air drag flow. Consequently, the Quest's design was the result of accurate studies rather than intuition or improvisation. The designer's idea was to have a faster vehicle but a less complex concept by adapting sophisticated aerodynamic solutions to a much simpler vehicle body. The production process also needed to be simpler. Given the designer's inexperience with glass-fiber and the relative high production time of the glass-fiber fairing, Allert Jacob decided to outsource the production of the fairing. Thanks to the network of recumbent and velomobile producers, he could find a firm that was able to produce high quality glass fiber ready to assemble, without plastering and painting. Therefore, the simpler metal frame production and the outsourcing of the glass fiber created the conditions for a simpler production system with a decreased production time.

Thanks to their experiences they accumulated at Flevobike, they were able to establish new functions for the technical, business and market development of the new firm. They showed adaptiveness to the evolving situation by carefully using their limited resources to achieve their goal. When the first Quest vehicles were on the road, the news spread rapidly through magazine covers and dedicated internet sites. This resulted in wide spread interest and potential

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<sup>7</sup> Ibid.

<sup>8</sup> Ibid.

customers. In a few months the J&S Company received about ten orders. After several tests and trails and errors, in Spring 2000, one year after building the 1:1 scale model, J&S shipped their first product.

### *The SAM*

The SAM is a three-wheel electric vehicle developed by Cree (Creation Research Engineering and Ecology), a Swiss start-up firm, founded in 1996. With two wheels at the front and one at the back, Sam (fig. 4) was specifically designed for short journeys in cities or in urban areas. Its first public appearance was in October 2001: *'Sam is a product half-way between a scooter and a normal car. It's specifically built for the mobility requirement,[sic] that means for one person to go from A to B.'*<sup>9</sup> The vision behind the SAM was clear: to create a new environmentally-friendly compact vehicle with zero emission for short distance, using an electric motor. This idea was not new: it was the same vision shared within the Swatch-Mobile consortium (with Swatch Watch Company as leader) in the early 90s in which one of the CREE founders was among the designers. When the Swatch-Mobile consortium lost Volkswagen as partner, the vision took a twist with the entrance of another large car manufacturer, Daimler Chrysler (at that time, Mercedes-Benz) in 1994. The new partner agreed with the idea to have a small compact vehicle, but with a small internal combustion engine rather than electric motor.



Figure 4. the SAM

The shift of the concept led to the development and launch of the Smart Car in 1998, but it also caused the departure, in 1995, of a group of designers. There was among them Marc Frehner, who disagreed with the new project direction.

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<sup>9</sup> Marc Frehner, Designer and CREE chief executive officer, Sempteber 2001, interviewed by 'Swissinfo', Swiss national magazine.

Committed with the original idea, he founded with other two engineers the Cree Company to exploit this opportunity. They were designers, and as such able to build such a concept, but to fulfill their dream they needed resources. Private equity investors that were close to the Swatch Mobile consortium helped the newly born firm, injecting around 8M€. With this capital invested they were ready to build the new vehicle: *'the new vehicle should have been between a scooter and a car, but not a car, otherwise it would have looked like a car and would have been compared and competed with it. The new vehicle should have been completely different: a three-wheeled vehicle. Also the price should be between the scooter and the car, around 6000€'*.<sup>10</sup>

Having decided the wheel platform, the designers focused on two specific requirements, to be build from scratch: the electric motor and the vehicle body. The standard electric motors on the market were seen by the design team inappropriate for the new vehicle, therefore they decided to build one with the help of Biel Engineers' School. The limited autonomy of every electric motor could be compensated by the short distance range traveled by car drivers. According to a study carried out on behalf of CREE, over short distances, most car drivers, almost 80%, are alone and it was this segment that the company saw as its market. The effort to build the propulsion system was rewarded by a functioning system for its first prototype build manually in 1997. It was patented after an innovative electronic control was developed and put in place in 1999.

The body was another challenge for the design team. They envisioned a plastic body, that could be resistant to torsions and acted as protective cover. Moreover, for low maintenance and production cost, the plastic body needed to be without painted parts. After only one year, the search for technical superiority resulted in a new double-walled thermoplastic body with no paint needed that was also patented. Therefore, the Cree Company could protect legally its own creature.

After the first prototype was completed, the Cree Company started to arrange the vehicle for the production system. The SAM was structured around three main modules: the body, consisting of only four separate body parts, the chassis with the drive module (steering and electric motor), and the batteries (14 lead batteries). The first individual modules were prefabricated by system partners, with final assembly done by Cree Company in Biel. After 5 years, a first pre-industrial series of 100 vehicles was ready for the first public and market test in 2001 in the Swiss cities of Zurich and Basel. It was very important for the CREE company to test both the vehicle and the public acceptance towards their creation. The support for such a vehicle convinced the Switzerland's second-largest retail group to acquire 80 vehicles and offer them to the public the chance to test the SAM. The reaction of the public was positive and many of

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<sup>10</sup> Marc Fehner, interviewed on September 23, 2002

them found the SAM fun to drive. Nevertheless, for many testers there were technical problems: the front wheel maneuverability, the closing system of the doors and the noise. The latter was found to be odd for an electric vehicle. Moreover, the propulsion system did not give guarantee of reliability and, although the vehicle was sophisticated, it looked unfinished.<sup>11</sup>

Despite the enormous publicity, the Cree Company was not able to start the production and attract more investors, while resources dried up swiftly. The project was pure R&D, where resources were fully devoted to, with no lead-user and few partners involved. In 2003 Cree Company went bankrupt, but not its dream, Marc Frenher is still in charge of his company and ready to reactivate the SAM as soon as investors will fully understand the potential of the SAM vehicle.

### *Mountain bike*

The mountain bike was not invented by a single creative inventor in a grand design nor was a full-fledged R&D department involved but it gradually developed in a series of steps by an increasing number of tinkerers within a community of user-developers. As a consequence, Berto (1999) and Buenstorf (2000) support the theory of a largely circumstantial and collective discovery of the mountain bike: no one invented it, nobody started out to change the bicycling world: it simply happened. The time was ripe for something better than skinny-tired ten-speeds. From the mid-1970s onwards hobbyists as user-developers started tinkering with old balloon-tired bikes and modified their frames and parts. Initially there was not much construction novelty and sophisticated design involved, but eventually this continuous process of experimentation eventually transformed the early mountain bikes completely and created the fully-equipped bike we know with frame geometry, derailleur shifting, cantilever brakes, thumb shifters, etc.

Despite its market dominance till the 1970s, the US bike manufacturer Schwinn had already started losing its competitive edge, first vis-à-vis the Europeans (e.g. Peugeot, Raleigh) in the 1960s, then to the Japanese (Bridgestone Cycle, National Bicycle, Centurion), and later followed by the Taiwanese (e.g. Giant and Merida) and finally to the Chinese (e.g. China Bicycles and Shenzhen) in the 1990s (Crown & Coleman 1996). The Schwinn company not only received one painful punch after the other in the main markets, but also lost contact with the new generations of users and failed to spot novel niche markets, manifesting itself clearly in South and North California in the 1970s and 1980s. In San Fernando Valley the motorcycle-style bikes for children (BMX) had been successfully developed by tinkerers, like Skip Hess, and bike manufacturing companyongoose, and BMX were in high demand.

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<sup>11</sup> Interview with Raffaele Domeniconi Manager director of Swiss VEL2 project, which supports the diffusion of electric vehicles. He witnessed one of the SAM testing (September 19, 2002).

A little up north in California in Marin County and a little later in time, another garage industry was reaching momentum, namely the tinkering on what later has become known as the mountain bike (in the words of Skip Hess: *an adult-sized BMX*, quoted in Crown & Coleman 1996: 112). Here innovation came from guys that were into stunt riding, dirt biking and off-the-road racing and after this cycling for the thrill they were (re)building their bikes in their garages. The Schwinn engineers looked down at the developers and hobbyists from Marin County; when they paid a visit to Gary Fisher's company (one of the local heroes then) in the early 1980s, they could not see any threat from the mountain bike user-developers: 'We know bikes. You guys are all amateurs. We know better than anybody (in Crown & Coleman 1996: 3)'. The first people on the mountain bike scene were young men in Marin County having fun with transforming regular road bikes (preferring among others the flat-tired Schwinn Excelsior originally from 1937) into an all terrain bikes in North. Many of them loved their clunkers (sturdy bikes based on old suitable frames collected from junkyards and using additional second-hand components, and spent most of their time thinking about them and ways to improve them. One of the co-inventors of the mountain bike, Joe Breeze, makes exactly that point: 'None of those involved had any great stroke of genius. We don't believe any of the participants from an early date possessed a clear vision about where the bike was going, and none of us was driven in any single-minded way to create a worldwide mountain bike craze (in Berto: p.84-85).'

While it may not be perfectly clear who invented the mountain bike, also the locus of the invention of the mountain bike contains a controversy. With all the succession of developments leading to the emergence and growth of a cottage industry for modifying old models to have better brakes and so on (making the so-called 'clunkers'), subsequently followed by the customized building and production of them, Marin County seems obvious. Tim DuPertuis acting as a predecessor of the new generation to come being the first to ride the flat-tire geared off-road clunker, but also Cupertino and Santa Clara Valley 75 miles south had a tradition of races involving a mountain bike pioneer like Russ Mahon riding his balloon-tired and derailleur-equipped clunker off-road already in the early 1970s. Both Tim DuPertuis and Russ Mahon left the emerging mountain bike community and industry in the making in the mid seventies. Those two pioneers in North California made their fair share to innovating the mountain bike by using flat tires and introducing derailleurs on their bikes. After their departure, the mountain bike chain reaction took off in Marin County, reaching a tipping point in the late 1970s and early 1980s; in the words of Berto (1999: 73): 'Mountain bikes just happened when enough of the early pioneers piled enough developmental logs on to the mountain bike bonfire. Critical mass was achieved and the mountain bike mushroomed.'" At the same time it died in Santa Clara Valley and Cupertino.

Already in the early 1970s downhill racing had become popular among the incrowd in Marin County, involving among others Gary Fisher, Charles Kelly, and Joe Breeze. Having seen DuPertuis and Mahon's derailleur-equipped bikes at cycle-races, Gary Fisher assembled the first 'clunker' in Marin County in 1974-75, which eventually became the progenitor of today's mountain bikes with all of the key mountain bike features on it, equipped with front and rear derailleurs, solid brakes, freewheel facility, double crank set, etc. Although most of the bikers and tinkerers were familiar with derailleurs of regular road bikes, it took some time before the derailleur was implemented and effectively being used by the group's own all terrain bikes: in the mind of the tinkerers, clunkers and road bikes, and their underlying technologies were clearly separated. The introduction of the gearshift changed the use of mountain bikes from basically confined to downhill racing and off the road biking to a much broader use including cross-country cycling allowing for long distance riding with uphill stretches as well. While the other users-developers did not publish their innovations, Gary Fisher did and continues to do so. Gary was actively linked to the further development and diffusion of mountain bikes.

The community of tinkerers also started to design purpose-built mountain bike frames; in 1976 designer Craig Mitchell built a completely novel bike for Charles Kelly with a innovative frame, and all kind of new bells and whistles. Unfortunately, the design was a failure, and two years in 1978 Joe Breeze, an experienced frame builder, designed and fabricated the first modern mountain bikes with new components, named the Breezer; It took him two years to build ten all-new mountain bikes. So the first custom-made mountain bikes and their frames were produced by active mountain bike riders, both for their own use, for small-scale sale to fellow bikers and subsequently selling directly to the customer. Also specialized suppliers manifested themselves, such as Tom Ritchey, a full-time bicycle frame builder and downhill racer; in 1979, his company Ritchey Designs provided frames into the bikes to be assembled by Gary Fisher and Charles Kelly's newly founded manufacturing company. In that year Fisher and Kelly had just established their own firm Mountain Bikes and had started with the large scale production for regular retail distribution. In order to protect the commercial use of the name Mountain Bikes, they also sought to trademark their company but failed in the end (the concept was too generic). A couple of years later in 1983, Fisher bought out Kelly and renamed his now fully-owned company the Gary Fisher Bicycling company, and began outsourcing the manufacturing of his bikes to its Taiwanese partner Anlen (ten years later Gary Fisher's Bicycle company was acquired by Wisconsin-based Trek Bicycle company).

As time passed, a number of the early biking pioneers after having spent most of their weekends designing, building and selling prototype bikes, became

missionaries for what became the mountain bike crusade. Some of the original tinkerers, organisers of the major off-road races, and publishers of magazines became founders of new businesses. Their commercial production activities evolved as a by-product of their leisure activities: from a hobbyist they had become an entrepreneur. A small-scale cottage industry in Marin County had come into being with some counter-cultural activities and a hippie flavour, where old roadster bikes were converted into 'clunkers' and sold to fellow mountain bikers and early adopters. Gary Fisher, Charles Kelly and Alan Bonds all started as refinisher of bikes and clunker assemblers. Starting in 1976, the first Repack races were held, organised by Charles Kelly. Although not commercially very successful, these races were very important for the further development of the bike because they provided incentives for improvement and trial and error learning, and coping with mechanical stress and reliability, acting as research and testing labs (Buenstorf, 2000). In 1980 the first mountain bike periodical *Flat Tire Flyer*, a quarterly newsletter-magazine published by Charles Kelly and Denise Caramagno as editors, was launched; the FTF became the voice of the mountain bike community for the first decade. Another hobbyist turned into a successful entrepreneur was Mike Sinyard, who had founded Specialised Bicycle Imports in 1976 and had started working with Italian parts manufacturers. Elaborating from the models Kelly, Fishers and Ritchey had put together in the early 1980s, Sinyard had these so-called Stumpjumpers mass-produced in Japan, subsequently imported them to the US and sold them at competitive prices already in 1982.

In the late 1980s and early 1990s, when the mountain bike industry had become more mature and had grown in considerably in size, a consolidation trend and new entry by more dynamic companies took place. The industry had developed into a more regular consumer good industry characterized by high-quality, innovative and fashionable products. The Marin County's inventors and pioneers had written the first chapters of the book on mountain biking by tinkering and clunking on old bikes such as the Schwinn Excelsior, but unfortunately they were unable to reap the rewards of their innovative and entrepreneurial activities. Everything was shared by the community of joint users and developers, nothing was patented or otherwise patented, hereby leaving room for smart followers and copy cats. Also on the losing side one can find the American biking institution Schwinn that went bankrupt in 1994, after several decades of mismanagement.

## **Discussion**

The cases studies give us the opportunity to discuss how the initial stock of resources and the chosen organizational form shape the innovation path and strategic actions of the entrepreneurs and firms in our sample. In this section,

we will focus on three main concepts that were derived from the literature overview, i.e. the type and quality of the resources, the initial organizational form and the chosen innovation and marketing strategy, the orientation towards the future and ambition level, namely the appropriability issue, that featured prominently in the mountain bike case.

*Resource-rich environment, strategic network, start-up firms and innovation/marketing strategies*

The quality and quantity of the resources in the initial stage of the entrepreneurial venture played a determinant role in shaping the innovation process. In the Mitka case, the coalition had a clear vision and plenty of resources to develop the new vehicle. Resources were not only in terms of amount of cash allocated to the project, but also in terms of human capital. Despite of the new challenge, designers, research institute and university knowledge brokers were able to employ skills and experience, while Nike and Gazelle were able to generate public interests with higher change to legitimize the venture. The great resources were employed to search and achieve a superior solution.

The Mitka team chose to take a large step in the design scale-up without engaging in-between simpler prototypes but going for the best solution. The product team's choices made the concept even more complex due to the number of new attributes and interactions. Furthermore, the team did not compromise the original attributes and avoided trading off of some attributes even in cases of apparent conflicts. Consider, for example, the choice of the vehicle width. Moreover, they seemed to be locked in the search for the perfect vehicle so they went for the most impressive engineering solutions.

More sophisticated market research was conducted at several stages of the process through surveys, group discussions, interviews and testing. Nevertheless, the users' preference and perceptions toward the Mitka did not entirely influence and shape the design and development of the Mitka. The lock-in effect of the design choices and the team's perception of doing something unique created conditions for dismissing user preferences that contrasted with the main development path, while highlighting favorable user preferences that, unfortunately, were proven to be minority views. They were reluctant to engage in and be associated with existing networks of skilled workers and practical technicians who have been developing similar vehicles.

In the SAM case, we can see a similar pattern. The Cree's founder left the Swatch Mobile consortium because of disagreement over the vision. He got money, skills and experience and he used to pursue his dream: a zero emission three-wheeled vehicle. After securing resources, the design team invested the

capital to build a superior vehicle, with no compromise with the original ideas. New superior features were developed such as the propulsion system and the thermoplastic body, but few attention was drawn on the market. Nevertheless the SAM was meant to be marketable vehicle, no public test or lead user test were performed before producing the pre-industrial series of 100 vehicle, neither concerns regarding the infrastructure were addressed. On the contrary, efforts and resources were addressed to create and protect technical superior solutions.

In the two cases, the search for the ultimate solution to mobility problems and the high ambition targets combined with the dismissal of user preferences and existing knowledge outside of the team evoke a breakthrough approach, as illustrated by Garud & Karnoe (2003). The cases' findings extend their work, suggesting how a resource-rich environment may trigger a breakthrough path (however, as also highlighted in the Segway case, the overambitious innovation and marketing strategy may not stand the feasibility and practical implementation test). *Proposition 1: Entrepreneurs with abundant resources are more likely to pursue a breakthrough approach, looking for complex and revolutionary solutions by full exploitation of resources.*

*Resource-poor environments, start-up firms, user-developer communities and their innovation/marketing strategies*

Compared to the conditions of resource munificence in the SAM, Mitka and Segway/DEKA cases, some entrepreneurs, operating in resource-constrained environments, succeed in creating something of value out of almost nothing, such as in the case of the Quest and the mountain bikes. The Quest and the mountain bike cases presented similar poor resource conditions in their early stage of the innovation both in terms of investment and experience. The Velomobiel founders were able to acquire technical skills and knowledge and market experience first working with Flevobike and later through learning-by-doing. Velomobiel's founders decided to take smaller steps in the design scale-up, and developed an in-between innovative vehicle, the C-Alleweder, to build technical experience and get useful feedback. In contrast to the previous cases, Velomobiel's designer decided to decrease the concept's degree of complexity, alternating innovative technical solutions with well-established practices. The design process was continuously adapted in the way that some attributes were compromised at the expense of others in search of a balance among the diverse requirements. To optimize the design, the designer opted for simple, yet elegant solutions. In the case of Velomobiel, the design choices were based on consumer's daily use. Their vehicles were developed to be used within the boundaries of current infrastructure. In contrast to the Mitka, for example the Quest's width was deliberately designed to allow the Quest to pass through doors and make use of both bicycle and car roads.

The first mountain bikers were even more laymen about the bike development. Through adaptiveness and resourcefulness, they were able to modify their bikes with resource at hand, tinkering, adjusting, learning by doing and experimenting. The combination of existing resources through trial and error created the opportunity of building a new type a bike. They started to play seriously (Schrage, 2000). Velomobiel's founders and first mountain bikers were engaged in a small, yet resourceful, network where technical problems were shared. These considerable interactions helped the entrepreneurs with limited resources strengthen their expertise and to be shape the emergent vision.

In both of the cases, they paid a great deal of attention to the feedback obtained through their extensive use of the products and that of the lead users. The continuous interactions with users created the conditions to exchange opinions and critical observations, which were coded as possible improvements. Moreover through competitions and recreational activities Velomobiel's founders and the first mountain bike entrepreneurs were able to grasp the perceptions and reactions of potential users towards velomobiles. Consequently, these exchanges created strong ties between entrepreneurs and the users, which increased the very legitimacy of their action. The recombination of resources at hand, the asset parsimony, the accumulation of knowledge through a sequence of innovative trial and error, the constant search for feedback and the attitude to adapt and tradeoff recalls the bricolage approach illustrated by Levis –Strauss (1966) Garud et al. (2003) and Baker and al. (2005). In contrast to Norhia et Gulati (1996), experimentations and trials & error activities are not the privilege of resource-rich environment. *Proposition 2: Entrepreneurs with few resources are more likely to pursue an innovation path looking for simple solutions by recombination of resources at hand, resembling the bricolage.*

#### *Emergent strategy vs. visionary strategy*

The development and diffusion processes chosen by the innovators reveals their entrepreneurial strategy. Different types of strategies emerge from the cases, here we focus on the two opposite ones: the emergent and the visionary strategy. The mountain bike (and to some extent the Quest case) case highlights how the Californian community was focused on specific problems where the solution came incrementally from tinkering and bricolage and through negotiation within the group. No great vision or strategy was guiding them in the beginning of the innovation process. During the process, some actors of the community started to envision a clear goal, behind the simple problem-solving paradigm. The founding of specialized company for mountain bike and the attempt to protect the invention are signals of an emergent strategy that was taking shape at the time. On the contrary, the SAM case shows how a clear vision and articulate strategy towards the future influenced the decisions of Cree's founders. The vision was not open to compromise as witnessed by the

exit from the Swatch-Mobile consortium. The resource-rich environment helped the Cree Company keep the vision alive where resources were used to give a shape to a radical idea. Also ongoing interest and support from the design community made that the SAM entrepreneurs gave priority to design and redesign, instead of attracting interest and feedback from marketing and distribution partners and end-users. As sheltered from the environment, the founders and designers could persist in their ongoing activities (resulting in almost overdesigning it) without have to take customer needs and requirements into account. In the SAM case, there was a deliberate and visionary strategy initiating and guiding the innovation and diffusion processes with few divergent steps from the planned and foreseen path. *Proposition 3: Entrepreneurs with few resources tend to adopt an emergent and dynamic strategy while entrepreneurs with rich resources tend to adopt an articulate and visionary strategy.*

#### *Challenging innovation networks and communities: the appropriability issue*

Strategic followers and later entrants, such as Trek Bicycling, Taiwan's Giant and China Bicycles, now clearly dominate the mountain biking sector. Other winners were the foreign parts suppliers Japan's Shimano and Suntour who had started to dominated the components market because of their successful appropriation of the various Marin County technologies and by introducing complete sets of components consisting of crank sets, gearshifts, hubs, and bottom brackets particularly designed for all terrain bikes. Another clear winner was Michael Simyard's Specialised Bicycle Components, who had clearly seen the enormous market potential beyond the community of hippies and tinkerers, appropriating non-protected models and designs by others, quickly mass-producing it and effectively capitalizing on all of this. The early pioneers of the mountain bike industry, like the hard-core hippies Joe Breeze, Gary Fisher, and Charles Kelly, all active in the (re)design of the mountain bike, simply because they did not patent any of their inventions, and relative Marin County insider like the almost natural-born entrepreneur Simyard and Shimano, and of course the foreign bike manufacturers mass producing bikes efficiently accrued the rents of invention and innovation. The Marin County/mountain bike community of practice was based on information sharing, cross-project learning, competition through racing and design, and fun, where appropriation and wealth generation was clearly not on the agenda; this naïve not-for-profit orientation made it easy for entrepreneurial outsiders to take advantage of the opportunities the mountain bike pioneers had seized.

Something similar happened in the Mitka, where the strategic network also could not effectively deal with the appropriability issue. In this setting, there was selective naivity and wishful thinking from the side of the government (the Ministry for the Environment being a big sponsor of the Mitka), the university

and the semi-public TNO research organization. In the Mitka project, the bike manufacturers Gazelle and Batavus were strongly looking into the appropriation issues (who would get the rewards after so many years?), either for screening alternative designs, getting into contact with new user groups, or simply leaving the project network altogether and taking patents and additional key knowledge with them. The appropriability issue is an interesting by-product of our study since we had not spotted it as to be discussed in our literature section on innovation management. Pioneering user-developer communities of practice and strategic networks may stimulate bricolage, cross-party and cross-disciplinary learning, but often forget about making money and wealth generation. The fact that new ventures potentially allow for the harvesting of the tangible and intangible efforts of inventing, testing/prototyping and marketing) and accruing the rents of all these activities, did not come to mind (or were not successful with their entrepreneurial firm or simply became marginalised by the competition from later entrants). *Proposition 4: Legal protection of the product innovation is a necessary but not sufficient condition for the growth of the entrepreneurial venture and its ultimate corporate success.*

## **Conclusion**

This paper has addressed how entrepreneurial process evolves and how it is shaped by resource availability. It is argued that the quality and the quantity of resources available at the beginning of the entrepreneurial venture determine innovation trajectories. The Segway case, as discussed in the introduction, has shown us how an idea for a new product and a novel market, taken on by an inventor-entrepreneur and building a new company for that purpose, are brought together in a new creative combination seeking to create wealth and take on the world. Four different constellations of resource configurations and chosen organizational form, as pictured in our 2x2 matrix, were discussed. The Mitka reflects a resource-rich environment with a strategic network as initial organizational form; the Quest case provides a clear contrast of the Mitka with operating through an autonomous start-up firm, operating in a resource-constrained environment. The mountain bike industry was propelled into entrepreneurial and strategic action by a community of users being developers as well, operating in a larger environment characterised by limited stocks of resources and limited concerns for appropriability issues. The SAM could be considered as our equivalent of the Segway, reflecting initial resource munificence and an independent start-up firm as the initial organizational form. The paper and the methodology applied are not without weaknesses. First, the case studies may describe an idiosyncratic phenomenon. Therefore, additional cases with heterogeneous resource environments in different organizational settings or industries may strengthen the results. Second, the findings are not tested because the new relationships were induced from the cases and

occasionally additional literature was selected to shed a clearer light on the cases. Further research can improve the generalization of the results by translating the propositions into testable hypotheses based on a large sample of entrepreneurial ventures.

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