Assessing the potential of new artifacts for sustainable mobility systems: the Mitka case

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Abstract

This paper presents a conceptual study on the contribution of new artifacts to the mobility system in terms of sustainability. Many innovative technical concepts are ready to be introduced into the mobility arena having the potential to enhance the sustainable potential, but many limitations impede these innovations to be implemented. In order to understand and avoid such barriers, a broad view should be contemplated during the process, in which many aspects of the present and future mobility system should be considered.

Within the urban and suburban boundaries the personal transportation system is the background for a problem setting, in which the car is still the most used means of transportation on short distances. In order to overcome the gap between the car and the bicycle a new mobility concept has been suggested as one of the potential solutions, the Mitka: a human powered vehicle characterized by three wheels and electric power assistance.

The paper assesses the potential of the Mitka concept in the context of the mobility system as one of the possible solutions for the negative externalities of the current transportation system such as environmental pollution, congestions and land use. It discusses in which conditions the Mitka can be integrated in the urban and suburban mobility system regarding the infrastructure, regulations, organizations and user acceptance.

1 Introduction

Constantly growing traffic in Europe leads to increasing environmental, economical and social problems, and deteriorates the competitiveness of economic activ-
ities and quality of life of its citizens. Currently transport is one of the main contributors to air pollution/CO₂ emissions and climate change, and in particular it is the fastest growing emission source.

On a local level, this means that the situation in urban areas is getting worse because of the increase of congestion problems, noise and uncovered infrastructure costs. In addition, public transport systems seem not to be able to provide for the needs of the car users [1]. On the other hand, transport services are indispensable to satisfy basic societal needs on mobility and accessibility. Their high standard of quality is a prerequisite and an enabling condition for local and national economic competitiveness [2].

In order to address these problems many measures have to be taken to pursue sustainable mobility and the necessary adaptations in our transport system.

But focusing on either “soft” measures (e.g. information or coordination of existing user services) which enhance the effectiveness of “hard” measures of traffic management (e.g. new bus lines or bike racks), or on the technological innovation, does not create the conditions to reach substantial improvement in the efficiency of production and consumption by a factor 4 [3] to even a factor 20 [4].

In order to have a sustainable mobility in the near future, the system should change into a more efficient, more reliable and less harmful for the environment one. It requires combinations of new technologies, new organizations and institutional arrangements, together with changes in use patterns and culture [5]: the system innovation. The Dutch environmental policy plan addresses the concept as transition [6].

An example is the research and development of Sustainable Product Service Systems, which often go not only beyond one product or one service [7], but also beyond organizational boundaries. They can be considered as a combination of long-term vision and short-term action. They are often developed on a system level, with a system being defined as a combination of products, services, organisations, rules, policies and (infra)structures, that all together enables the user to fulfil a certain need [7, 8, 9]. In order to implement these complex solutions in short term, it requires more than merely focusing on the functional aspects of the innovation. If an artefact and/or a product-service system is to function properly, then it has to find for itself a space within the system, overcoming the barriers on the system level, co-evolving with its social context.

In order to understand the dynamics of this co-evolution and the factors involved, the paper takes into account the contribution of the Mitka to the mobility system in terms of sustainability. In section 2, the Mitka system is described, section 3 illustrates the barriers and the facilitating factors for the adoption of the Mitka, and the last considerations and conclusions are summarized in section 4.

2 The technology and its contest

The Mitka is an example of an individual means of transportation within the urban and suburban boundaries with its three wheels and an electric engine to assist human power.
Mitka is a Dutch abbreviation that stands for (translated): “Mobility solution for individual transportation on short distances”. The Mitka-system is being developed as a sustainable mobility solution for short distances, aiming to reduce the amount of car kilometres [7], knowing that 80% of the car-trips made in Netherlands are rides in between 5 and 20 kilometres [10]. The Mitka was designed for a specific function: to transport commuters from home to work. It is characterized by some specific feature, like the roof for weather protection, flexing wheels and the power assistance to drive in an easily and comfortable way.

The idea is that people will use the Mitka instead of the car and thus use less energy in regular (home-work, shopping, visiting) transportation. However, the Mitka is not just a bike-up concept, but also a product-service-system with the ambition to create a new market sector for short distance mobility.

The coalition of partners behind the Mitka is formed by: TNO (Institute of Industrial Technology) as project leader, Gazelle (bicycle company), Peter van der Veer Designers (product development and design), Freewiel Techniek (engineering), Delft University of Technology (consumer research, ergonomics and development of Eco-efficient services) and Nike company as lead users.

Throughout the Mitka development the user involvement has been regular [11]. Through group discussions and an internet survey for the Nike employees, and a questionnaire in the bicycle fair, the user was helpful not only for the evaluation of the artefact but also for the designing services to make the Mitka part of their daily life. The Nike employees are the lead users and selected employees will test their travel with the Mitka from work to home in a pilot project in August 2002. The aim of the test is to evaluate both the technical functioning of the Mitka, and the product service combinations, which are designed to enhance the value and the meaning of the Mitka for the potential users. With a real-life test it is possible to identify the interaction among the new technology and the short distance mobility system, here represented by a ray of 10-20 km around the Nike headquarter as a focal point. Doing the test many barriers can be identified and measured due to the interaction with the system. In the next section the opportunities and barriers in the system are evaluated within a conceptual framework.
The Sustainable City II

3 Barriers and facilitating factors for adoption of Mitka

The interaction between a new technology and the existing system can create tension and barriers can obstruct its introduction. M. Staudenmaier, a historian of technology, used the concept of "the cultural ambience" to highlight the "atmosphere" which permeates a technology and without which it cannot survive [12]. In fact any novelties should find the own space in the system, having difficulty in doing so because they are different significantly from the technologies in the existing system.

Hård and Knie adopted this thesis evaluating failure in the automotive industry, saying that market success requires that the inventors either accommodate the existing cultural ambience, or that elements of this ambiance are modified to accommodate the novel device. In both cases, strategies have to be developed to open up the appropriate space within the ambience [13]. The cognitive patterns and practical routines are stressed here as important factors.

In order to create an implementation strategy, according to the "strategic Niche management" approach, new radical solutions require protected areas within which to develop a momentum, called Technological Niches [14]. In general, innovation experiments fail for any number of reasons. These include technological barriers, policy failures, the underdevelopment of the market and the infrastructure, uncertainties about environmental or other benefit of new technologies and an attachment to the values associated with existing ways of doing things, such as the flexibility and freedom of the private car. Consequently successful innovation towards sustainable development in transport is a matter of technology but also a matter of socio-economic context, mental frameworks of individual behavioural, institutional and organizational patterns [15].

It is important to understand and identify these patterns along the project of innovative concepts. In this phase of the Mitka process, the recognition of the system and its cultural ambience turns to be useful for the follow-up of the project. In fig.2 some of these characteristics are visualized. The left-side circle represents the technological artefact, Mitka, and its key characteristics that play a role in its adaptability to the existing "cultural ambience". It includes its appeal to the consumer and its main features and functions. The right side circle signifies the system. Five general characteristics of the system play a key role in creating barriers and facilitating factors for "admitting" the new technology. They are the infrastructures, the regulations, the user acceptance, the organizations and networks, and finally the environmental factors.

3.1 Infrastructures

Watching the Mitka on the bicycle path driving faster than the car on the congested road is an appealing dream, which could come true, but currently the Mitka is too wide for it; the Mitka may not fit well in the current transport system. Another obstacle can be the facilities needed to store the Mitka. The storage has different functions: to provide a "space" close to the user, to protect from the
weather condition and to prevent vandalism acts. Thus facilities both near the office and the house should be provided for storage.

The possibility to store the Mitka depends also on the characteristic of the location for example in the sub-urban area and in the countryside; houses have more space (sometimes equipped with gardens or a shelters) than apartments in the city. On the other side big companies can provide facilities for Mitka, but small companies cannot.

![Figure 2. The Mitka and its cultural ambiance](image)

As a power assisted vehicle, the Mitka needs a recharge unit for the batteries in the different locations mentioned before and possibly also along the way. The batteries can be recharged from the existing electricity grid, but specific facilities should be designed and provided for households and/or offices.

Another adaptation to the infrastructure concerns vehicle maintenance: mechanics must be acquainted with the new technology in order to be able to offer services and repair the vehicles [16].

The Mitka needs this infrastructure and maintenance from the very beginning to be adopted by users. But on the other side, only with a high number of vehicles does it become profitable to create such facilities and services.

### 3.2 Regulatory framework

The Government in this context plays a double role. On the one hand, the government has an active role subsidizing the Mitka project through the Move Program; on the other hand it functions as regulator. Thanks to subsidiary programs, many projects with sustainability as a driver can start and develop.

However, the existing regulatory framework may form a barrier to the development of new technologies. The power assistance of the Mitka allows the user to drive up to 40 km/h. In this case the user needs a helmet according the safety regulation, which contemplates the use for more than 25 km/h. In the meantime, human powered vehicles do not have any law restriction.

As previously mentioned, on the bicycle path the Mitka could avoid traffic jams and congestions that occur on the normal road adding the feeling of flexi-
bility and safeness. The current Mitka is 90 cm wide (due to the flexing wheels and the pedals [17] and, according to the road regulation, any vehicle wider than 75 cm cannot ride on the bicycle path due to safety reasons. Moreover, in “walking cities” like Amsterdam, where the human dimension is reflected in the urban structure, the Mitka can be perceived too wide for the small roads by commuters.

### 3.3 User acceptance

For an artefact to be accepted by potential users, it is necessary to convince them that the item can be easily and advantageously integrated into the routines of daily life. To reach public acceptance, it is of utmost importance that the new technology acquires meanings and connotations that make it possible to comprehend and comment upon it [13]. Values such as flexibility and freedom are associated with the possession of a car. Moreover for many people, the car is also the expression of status and social identity [15].

The image of the car has been translated to the design of the Mitka. The potential users found it attractive and the ones who have ridden on it also found it fun and comfortable and manoeuvrable, creating a high expectation around the Mitka. Another positive factor is the changing attitude towards the electric vehicles, which is often associated with, for instance, a disabled person’s vehicle. In this case the electric help has been evaluated positively. The meaning of the battery is related to the possibility to go faster than the bike. On the other side of the coin, speed is an important factor for user acceptance: if in the bicycle path the Mitka, riding at 25 km/h without helmet (according to the regulation), is overtaken by a normal bicycle with maybe an old man on it, it will lose its sporty and attractive image. The same thing can happen if the rider is obliged to wear a helmet (driving more than 25 km/h), which could be considered unappealing. Moreover, the battery-powered limited range of the Mitka could force the users to adapt their travel behaviour.

In general, for potential users the Mitka should be compatible with the existing values, norms, beliefs and past experiences with the car or bike. Shifting from the car to Mitka in short distance travel should reflect this consistency. For instance, the Mitka should be accessible, very near the office and home, safe-stored, flexible, fulfilling other functions like shopping, and easy to use. An innovation that is perceived complicated and not consistent with these characteristics by potential adopters diffuses very slowly or is even refused [18].

### 3.4 Organizational factors

In order to have a successful technology, it is necessary to create a manufacturing organization and to construct networks of firms and authorities that are devoted to the continuous maintenance of the technology and its sub-elements [13].

A chicken-egg problem is related, from a demand side, to the price and, from the supply side, to the mass-production. Innovative technologies are often too
expensive due to the small production and on the other side the mass production is a risky and long process.

Another very important aspect is “the web” that needs to be created around the Mitka, the kind of services and facilities necessary for the placement in the mobility system. Expert organizations in providing such services and facilities should be enlisted in the Mitka network. The Mitka ownership, its maintenance, parking space and protection, its legal framework, should be arranged by a new organization or by established ones. This could create space for business opportunities for both the Mitka consortium and for other entrepreneurs.

3.5 Environmental factors

New technologies can solve some problems but can create others. In this case, the Mitka has been thought as a sustainable concept because it should be an alternative to the car and not to the bike. Apart from environmental considerations about the production of such a technology, a very important aspect is the usage. Using the Mitka for daily travel to work instead of the car leads to an environmental gain even if not easily quantified. If the Mitka is adopted by users and regularly used as a well-recognized and established concept for commuting, it can replace or even avoid buying a second car. This would result in a consistent environmental improvement regarding the Mitka as a sustainable transportation vehicle. It depends to what extent the Mitka system will diffuse in the cultural ambiance and in the mobility system. In order to keep the bikers riding the bike and the public transport commuters using the public services, special attention should concern the service design for the potential Mitka users. Services should attract car drivers, let them leave the car at home and push them in using the Mitka regularly. Some of these services are listed in TNO publications [19].

Another possible negative environmental impact and socially undesirable impact is related to the batteries. The nickel-Cadmium and nickel–metal hybrid batteries are assessed as highly toxic, causing health diseases. The only sodium-sulphur and lithium-polymer might be better for the environment. Probably in the future the Mitka could be powered by fuel cell, a new technology not too far from reality as the first bike prototypes show, the example of “Aprilia Enjoy” [20]. An environmental assessment should be done to know exactly how the Mitka usage would contribute to create a sustainable mobility system (a preliminary study has been conducted for this purpose [21]).

4 Considerations and conclusion

Table 1 summarizes the facilitating and constraining factors for the Mitka’s introduction. The Mitka has a high potential to be integrated in the users’ routine and in the organizational and infrastructural patterns. In term of sustainability the Mitka, meeting the favours of the car users, can be a breakthrough among the means of transportation. In order to meet these expectations, many barriers have to be understood and overcome. Thus the question is: how to tackle the barriers? An implementation strategy is needed.
Three different scenarios could be used. The first is *not* to do the experiment until the legal and regulatory framework is translated into the technical design and all the services and their institutional agreements are ready to "receive" the Mitka in the mobility system. But postponing the test to an unknown date could be risky for the Mitka coalition and for its technical development. An endless process could stop without any results.

Table 1. Opportunities and barriers' scheme.

<table>
<thead>
<tr>
<th>Function</th>
<th>Opportunities</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Home-work travel</td>
<td>Limited use for shopping or for transporting kids</td>
</tr>
<tr>
<td></td>
<td>Dry (Weather protection)</td>
<td>Limited roof protection</td>
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<tr>
<td></td>
<td>Fast (power assistance)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Easy and comfortable (ergonomic and technical development)</td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Using bicycle path, avoiding congestion</td>
<td>Too wide</td>
</tr>
<tr>
<td></td>
<td>Current electric grid for recharging batteries</td>
<td>Space needed for parking especially at home</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recharge unit difficult to locate out of the home/office</td>
</tr>
<tr>
<td>User acceptance</td>
<td>Fun</td>
<td>Wrong image (too slow or too garish)</td>
</tr>
<tr>
<td></td>
<td>Attractive</td>
<td>Complicated (hard to integrate in their routine)</td>
</tr>
<tr>
<td></td>
<td>Safe</td>
<td></td>
</tr>
<tr>
<td>Organization and network</td>
<td>Entrepreneur</td>
<td>Mass-production vs. price</td>
</tr>
<tr>
<td></td>
<td>Enlisting service providers</td>
<td>Insufficient knowledge within the coalition</td>
</tr>
<tr>
<td>Regulatory framework</td>
<td>Subsidies</td>
<td>Speed limit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Helmet use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Using roads instead of bike paths</td>
</tr>
<tr>
<td>Environment</td>
<td>Sustainable concept as alternative to the car</td>
<td>Used by bike riders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use of batteries</td>
</tr>
</tbody>
</table>

The second scenario contemplates to do the experiment anyway, without taking into account these barriers and facing them when this will occur. This approach could be also too risky because in case of incident it will create a damage of image and any further developments could stop.

The third scenario is based on *Niche management*: design the experiment considering protective measures. From a legal perspective, local and regional political institutions to allow the Mitka to ride in the current bicycle path should release authorizations. In order to store the Mitka, the *pioneer users* should be selected among the car drivers who have enough space for the Mitka, for example in the garage or in a shed where also the batteries could be recharged easily. Parking and recharging facilities should be provided in the Nike Company's buildings. The necessary services should be prepared, for instance, the maintenance and repair
service as well as the 24-hours service assistance. Nevertheless, the technical arte-
fact should be ready and in perfect condition to cope with such a test.

From these scenarios, a couple of elements can be identified. First, in order to
tackle the barriers, a prioritisation could lead to a less risky and more effective
implementation strategy. However, a prioritisation could be enough to have a
successful experiment but maybe not enough to lead to a successful niche for-
mation.

The second element is the dissonance. The barriers, even if connected, have the
own dynamics. During the process development, specific choices can lead to tack-
le particular problems while creating the space for other opportunities and barri-
ers. In our case study, specific limitations were perceived around the artefact’s
technical development, but much less attention had been paid to the system level
(where the cultural ambiance is an important factor for the failure or the success
of the innovation). Thus, during the process, it occurred a disharmony of the two
domains: the technological artefact and the system. Moreover, problems can occur
inside the coalition, where miscommunication, no real commitment, different
expectations or lacks of knowledge can slow down the process.

These internal and external limitations do not occur at the same time but along
the process. Therefore many of these could be identified during the project
development, instead of facing them in the pilot project possibly resulting in a
failure. Hughes defines such barriers, which slow down the process as reverse salients [22]. These will be established as a critical problem, whether the system
builders will perceive them as such. System builders translate these reverse salients
into critical problem and if these problems are solved, the system is able
to continue its growth [23]. The question is where and when in technological
development these factors should be asked. The importance of having a broader
vision of the Mitka and its “cultural ambiance” seems to be needed for the suc-
cess of its development and implementation. But how to translate the vision in
an effective approach for the process is still uncertain.

These questions will be investigated further as part of the research program in
the “Design for Sustainability program” section of the sub-department of
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