INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED'09
24 - 27 AUGUST 2009, STANFORD UNIVERSITY, STANFORD, CA, USA

ASSESSMENT OF USER NEEDS FOR AN ELECTRIC-POWERED PERSONAL TRANSPORTATION UNIT IN URBAN ENVIRONMENT

Markus Eurich, Nadia Jamali, Karin Löffler
Chair of Technology and Innovation Management, Swiss Federal Institute of Technology Zurich

ABSTRACT

This paper presents the results of a usage study of an electric-powered personal transportation unit in urban environment. The study is based on a qualitative and quantitative data analysis, which is divided into three phases: In the first phase, called "Expectations", face-to-face interviews were conducted to figure out participants' expectations towards the usage of the unit. In the second phase, called "Perceptions", the participants were asked via an online questionnaire about their opinion of using the unit for their daily commute. In the third and final phase, called "Experiences", the participants were asked through a face to face interview about their overall experience with the vehicle in urban environment. Moreover, questions about the hardware and functionally of electric-powered transportation units were asked. The study results show that electric-powered personal transportation units can be used in urban transportation, however only with some restriction, such as traffic regulations that would have to be changed.

Keywords: User needs, technological innovation, design to regulation

1. INTRODUCTION

The overall goal of this study is to foster the understanding of possibilities for using an Electric-powered Personal Transportation Unit (EPTU) as an alternative way of commuting in a traffic dense European city. An EPTU is a relatively small, 2-wheeled device, powered by an electric engine, which provides personal mobility and can operate on no motorized facilities such as trails, hallways, and multi-use paths. The study focuses on questions related to commuting behavior, mobility aspects, the perception of and experience with those units, as well as hardware and functionality of the units. The results are based on a four months user study of electric-powered personal transportation units, used for commuting to work by 30 participants in Switzerland. As one result, it is described how the units have been accepted as road vehicle and what challenges were to overcome. In a second stage, design changes required by law are discussed.

2. METHODOLOGY: EMPIRICAL DATA AND STATISTICAL ANALYSIS

The research goal and question is centered on the expectations, perceptions and experiences from using electric-powered personal transportation units as alternative urban transportation commuting vehicles. This is the first study performed to answer these questions, which means that there are no data from previous studies to compare with. Instated a holistic approach is taken to make sure all possible aspects are being considered.

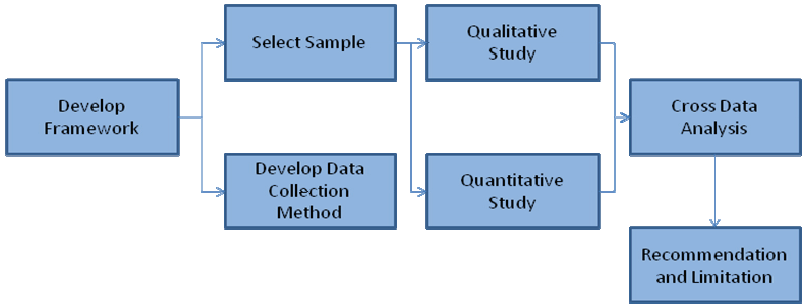

Figure 1. Qualitative and Quantitative Data Analysis

A qualitative and quantitative research study design was selected as most suited to the objectives of this study in order to come up with valuable final recommendations (cp. Figure). The study research approach was chosen to support the investigation of when and how an electric-powered personal transportation unit can be used as an urban transportation vehicle. Figure 1 shows the research methodology steps, which were approached for this study. After the development of a concept framework for the study, the next steps included the selection of the participants sample and the development of the data collection methods in form of questionnaires with qualitative open ended questions and quantitative closed questions. A cross case analysis of the selected data was performed to give valuable conclusions of the study with fact based recommendations of the study results.

2.1 Study Sample Description

30 people, all employed by a Swiss Insurance company, were chosen as participants. This location and this group of participants have been chosen to enable a representative sample of users in metropolitan areas in Europe. The group of participants has been selected in a pre-study to cover various age groups, both genders, all typical commuting habits and distances, and all motivations, ranging from being fascinated by new technology, preserving nature to practical considerations.
Most of the participants own a car and two bicycles in their household, they use to commute mainly per car, live on average about 575 m from the nearest bus or train station and on average 13km away from the office (while most live within 6 km), and spend about 27 minutes on average for their daily commute. All participants were provided an electric-powered personal transportation unit for commuting for a timeframe of five weeks.
The study is divided into three phases:

Phase A "Expectations": Pre-usage Stage

The data collection for phase A was done through face to face interviews guided by a questionnaire, each of the 30 interview sessions lasted about 30 minutes. The interviews included questions about general commuting habits as well as questions related to the expectations towards an electric-powered personal transportation unit in an urban environment. The results of phase A for the study show that 29% of the participants have an annual income between CHF 156k-260k (approximately USD 140k-230k; cp. XE 2008), 28% are in the age range 40-44, 39% live in a household of two persons, 45% own one car, 31% own three bicycles, 55% us their car for daily commute, 44% spend 10-30 minutes for their daily commute, 39% live < 5 km from their office, and 55% live between 50-500 meter from a public transportation station. As summary the chosen candidates are the perfect sample for the study.

Phase B "Perceptions": Using Stage
In phase B, after 18 days of using the unit, the questions were related to participants' perceptions of the unit. The second round data was assembled via an online survey. The subjects were addressed personally and had the opportunity to answer questions concerning their perceived feeling while riding the unit. The questions asked aimed at learning about the experience made and perception felt by the subject during their trial. Accordingly, the questionnaire was structured in two parts. Whereas the first eight questions asked the participants in what way and to which extent they used the vehicle, the second part focused on personal experiences made during these first weeks of the study. Moreover, a temporal comparison of all three rounds had to be achieved by asking identical questions throughout the whole survey. During this stage of the study the daily weather conditions were monitored, showing that out of the 18 days, there have been 12 dry days, 4 rainy days and two days with mixed weather conditions of rain and dry.

Phase C "Experiences": Exit Use Stage
In phase C, after five weeks of usage, the participants were interviewed again in 30 min face to face interview sessions. The questions in this round were focused on the overall experience with and perception of the electric-powered personal transportation unit. Therefore the questionnaire comprised questions about hardware and functionality, perceived convenience of, and the overall experience with the usage of the unit.
Out of the 30 interviews, 25 were conducted face to face, while the remaining five had to be conducted via phone. Each interview followed a structured questionnaire that was composed of open and closed questions. After five weeks of usage, the participants became experienced in riding the unit. Therefore, the results of this round can be considered as being the most meaningful.

3. RESULTS OF THE EMPIRICAL STUDY

This section focuses on the data analysis of the three study phases.

In the second round of interviews, the participants were asked to rate given statements about the electric-powered personal transportation unit (Figure). This question aimed to estimate the role of the unit in everyday life and its possible impact. The questionnaire form provided ten statements about the Electric-powered Personal Transportation Unit, which were to be rated on a scale from 1–5 indicating the respondents agreement (1 strongly disagree – 5 strongly agree). The answer sheet allowed multiple answers. Figure illustrates the results showing the users' agreement in most statements, particularly in "enjoying life" (70%), "meeting new people" (60%), "decreasing dependency on oil" (59%) and "bettering the environment" (52%). As many users either possess an annual card for public transportation or use their bicycles (i.e. expenses already incurred) strong disagreement occurred with "saving money" (82%). Due to previously mentioned issues such as high traffic density, low speed and far commuting distances (>10 km), "saving time" was not rated as a characteristic of the unit's usage (67% disagreement) either. However, people who stated to have been using the electric-powered personal transportation unit for leisure and other spare time activity rated it to be useful to save time (7%). According to the demographic data, these users are usually bound to public transportation and feel to have become more flexible during the unit trial or live within a distance of less than 20 minutes commute.

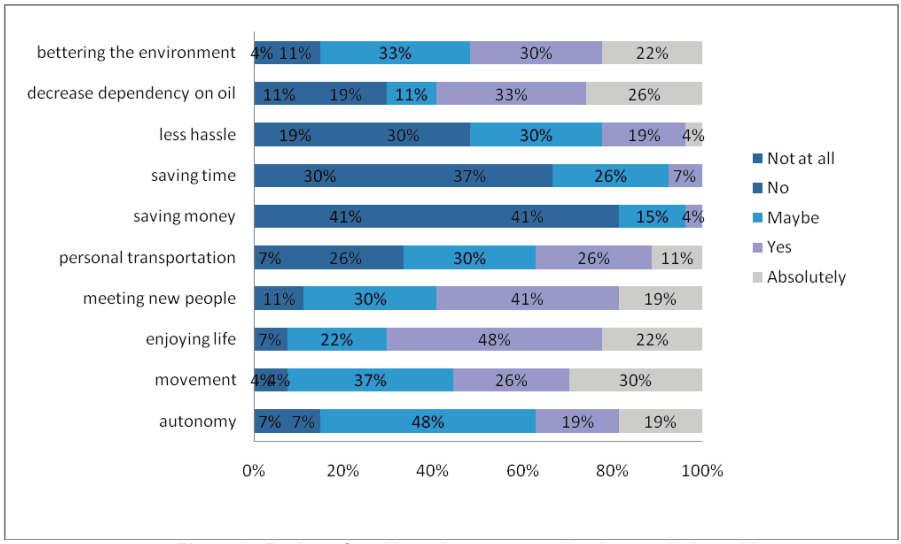

Figure 2. Rating of multi-mode transportation in correlation with an Electric-powered Personal Transportation Unit

The final round of interviews focused on the participants' overall experience with and perception of the electric-powered personal transportation unit. Therefore, the questionnaire comprised questions about the following: hardware and functionality, perceived convenience of, and overall experience with the unit.

Hardware and Functionality

The first part of the questionnaire was about hardware and functionality of the electric-powered personal transportation unit and included questions about parking it and desired product features.

The question about desired product features revealed a large variety of potential modifications. Most interviewees would appreciate a speed that ranges from 25km/h to 40km/h. Many participants want to ride the electric-powered personal transportation unit at about 30km/h as this is the speed they are used from small motorbikes, scooters and the like. Furthermore, many participants wished a smooth suspension, a good breaking system; great ergonomics, a good lighting system, low weight and a rear-view mirror were further frequently stated product features.

Perceived convenience of and overall experience with the electric-powered personal transportation unit

The second part of the questionnaire included questions about saved time, saved costs, the expected role of electric-powered personal transportation units in urban mobility, perceived easiness of riding, perceived reliability, the extent to which participants became more mobile, situations in which the unit could be a better option than a car, the appropriate commuting distance, and the overall experience with the electric-powered personal transportation units.

19% of the participants think that they could *save time* on their commute by using the of electric-powered personal transportation unit. Most of those commuters who believed that they could save time were used to commute with public transportation. None of them used to take a bicycle for commuting. Some of the participants who claimed that they could not save time on their commuting reported to be faster with the car or the bicycle. Some others are faster by using public transportation as they benefit from good connections. Overall, some users think that the electric-powered personal transportation unit might be a faster option compared to a car in case of traffic jam.

Only one out of three users (35%) believes that she or he could *save cost* by using the electric-powered personal transportation unit. The main argument was that they believed that they could save cost due to saved fuel. However, they expected that you could save cost only in the long run. Most interviewees are convinced that even if the unit could replace the car for commuting, the unit cannot completely replace the car at all. Consequently commuters still need a car and therefore fixed costs of a car cannot be avoided.

More than half of the participants (56%) estimated that the electric-powered personal transportation units will have a *role to play in urban mobility*, but most interviewees saw the units' impact only with restrictions. According to their estimation, electric-powered personal transportation units will only have a not negligible role to play in urban mobility only if traffic regulations change. The unit needs to be allowed to run faster (currently the Swiss law imposes 15 km/h) and should be allowed to be used on cycle lanes and in pedestrian zones. Many interviewees currently perceive the urban area as not being very suitable for the unit: Bicycle lanes on the road are too narrow, the traffic is too dense, and appropriate parking places are missing.

The next three questions are about the perceived easiness to ride, reliability, and handling of the unit. Interviewees were asked to rate their perceptions on a scale from 1 (bad) to 5 (good). For the sake of readability the numbers were given names as depicted in **Figure 3.** , **Figure 1**, and **Figure 2**.

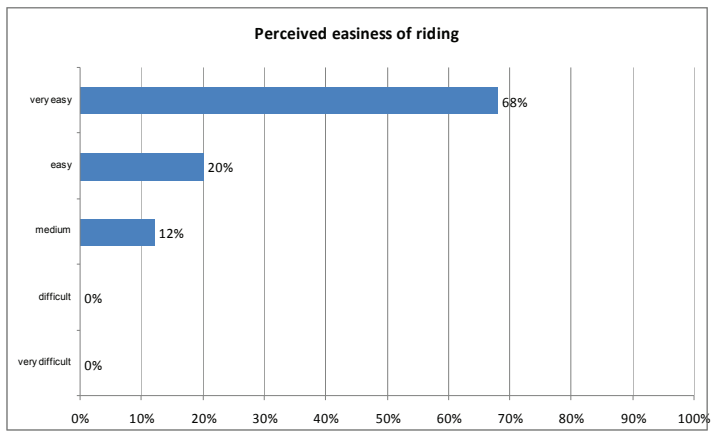

Figure 3. Perceived easiness of riding

Overall, most participants found it very *easy to ride* the electric-powered personal transportation units that has been provide for the study (cp. **Figure 3.**). They praised the very short time needed to learn to ride it, the easiness of balancing and the intuitive way of riding the vehicle.

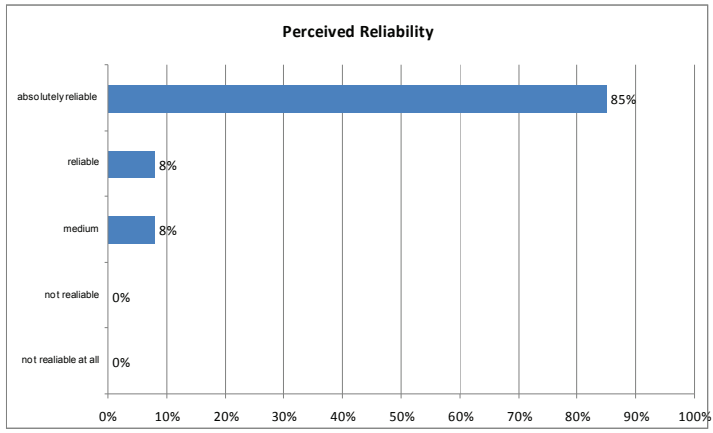

Figure 1 - Perceived Reliability

The unit was perceived as a very *reliable device* (cp. **Figure 1**). This is in line with the question about hardware or software problem that revealed that most interviewees were not faced with any problems and those who were mainly faced with minor issues like an instable or broken kick-stand.

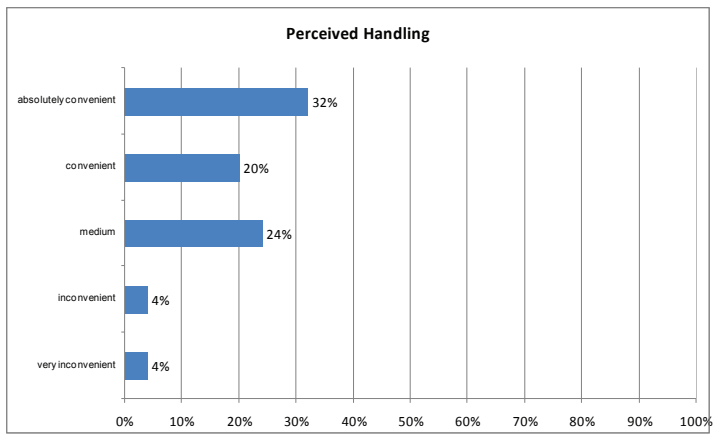

Figure 2 - Perceived Handling

The *handling (in terms of getting around with the device, i.e. to commute to work, which can include mounting it into a train, tram or bus) of the unit* tends to be perceived as rather convenient (cp. **Figure 2**). 52% (32% "absolutely convenient"; 20% "convenient") had nothing to complain its handling. The unit was often perceived as an inappropriate item to put into a trunk or to mount into a train as it is too heavy and too bulky. Therefore, many interviewees think it is complicated to use it in combination with local public transportation. Thus the handling of the electric-powered personal transportation unit seems to be perfectly convenient as long as you do not have to carry or mount it.

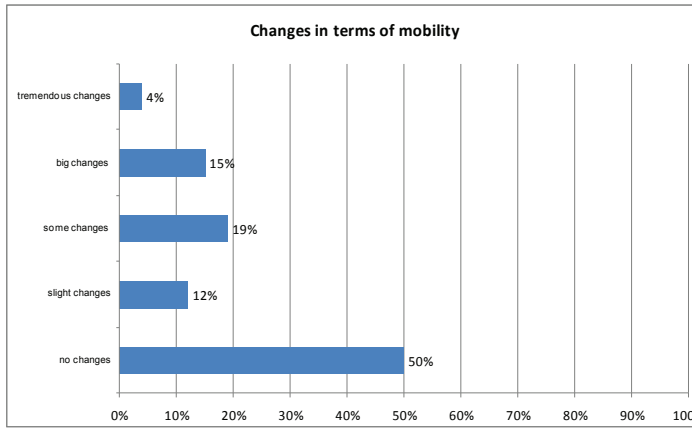

Figure 3 - Changes in Terms of Mobility

Half of the interviewees realized *changes in terms* of mobility due to the unit. For the other half nothing changed in terms of mobility: They took the same commuting route as they used to and went straight back home after work. A few reported that they visited places they have not seen before, chose pathways which have so far been inexperienced, and went to town more often. There is no evidence to ascribe the level of perceived changes in terms of mobility to demographic data or commuting habits.

83% of all participants experienced *situations, in which the unit was particularly convenient*. Commuters appreciated the increased flexibility and spontaneity. They were free to come and leave the office whenever they wanted to and did not have to stick to train or tram schedules. They considered the unit as being very convenient for short distances, enjoyed riding it uphill, and easily finding a parking place. Commuters found it very useful to get around traffic jams. Many participants found themselves in convenient situations, like to go clubbing, shopping, and to run errands.

All commuters (100%) underwent *situations, in which the electric-powered personal transportation unit was particularly inconvenient*. Inconvenient situations could stem from external circumstances like road conditions, traffic regulations, and narrow bicycle lanes that almost caused accidents and disturbed other road users. Parking the unit could yet be another possible origin of inconvenience: It is sometimes not easy to find an appropriate parking place in town, storing the device at home could be problematic, and some commuters were frustrated by the loss of flexibility due to the fear of damage when leaving the unit outdoor.

Beside useful, convenient, and inconvenient situations, the study detailed situations in which an electric-powered personal transportation unit could be a better option than a car. The unit could especially be preferred to a car, to evade traffic jams, to easier find a parking place, and for short distances. The unit could be preferred to a car for going shopping, commuting, and to save energy.

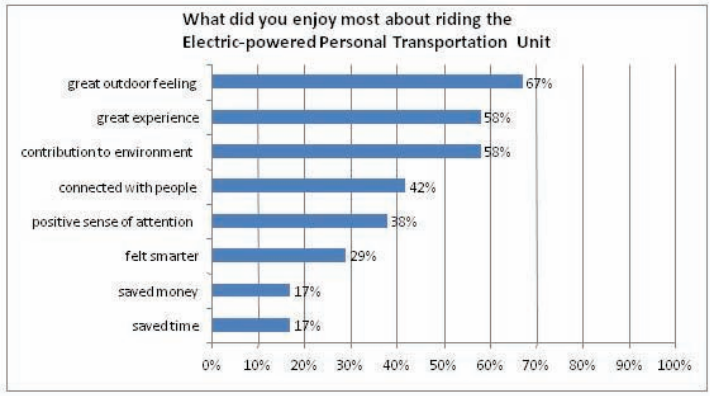

Figure 4 - Sources of Enjoyment when Riding an Electric-powered Personal Transportation Unit

After having the opportunity to ride the unit for five weeks, the participants of this study were asked *what they enjoyed in this time about riding the unit* (cp.Figure 4). Most participants appreciated the great outdoor feeling (67% of all participants) and many participants liked the great overall experience as well as having a share in contributing to the environment (58% each). The joy of getting connected with other people (42%) and a positive sense of attention (38%) were shared by at least one out of three. Further characteristics that go along with the unit like feeling smarter (29%), saving money (17%), and saving time (17%) did not score high in users' perception.

The interviews aimed at learning more about electric-powered personal transportation unit's perception and brand personality. Therefore, the participants of the study were asked how they perceive a *typical electric-powered personal transportation unit user*. The interviews suggest four different user profiles:

1. The *lifestyle-oriented* (Table 1) *trend-setter*, who is trendy, progressive, cool, modern, and dynamic.
2. The *ecoconcious*, who is outdoorsy and supports the preservation of natural environment.
3. The *technology enthusiast*, who is smart and technically accomplished.
4. The *bohemian*, who is unconventional, extroverted, and revolutionary.

Table 1: What an Electric-powered Personal Transportation Unit is about

EPTU is about	Average	Standard deviation
personal transportation	4.11	0.88
lifestyle	4.05	0.97
movement	4.00	1.15
autonomy	3.95	0.78
enjoying life	3.89	0.81
decreasing dependency on oil	3.79	1.32
bettering the environment	3.63	1.12
meeting new people	3.47	1.22
saving time	2.68	1.00
less hassle	2.53	1.02
saving money	2.53	1.47

After the clarification of how a typical user could look like, the next question was how the vehicle itself is perceived and *what an electric-powered personal transportation unit is all about* (cp. Table 1). Therefore, interviewees indicated their agreement with eleven statements on a scale from 1 (standing for 'strongly disagree') to 5 (referring to 'strongly agree'). There was a strong agreement for the units being about personal transportation, lifestyle, and movement. However, the views that the units could be about saving time, saving money, and less hassle was not shared by many users. The perceptions that the units could be about decreasing the dependency on oil, saving money, and meeting new people was controversially discussed: Some people share these points of view others do not (cp. high standard deviations: Table 1).

The second part of the questionnaire concluded with a rating of the *overall experience* made with the – electric-powered personal transportation unit provided for the study (cp. Figure 5). The rating scale ranged from 1 (meaning 'totally miserable') up to 5 (referring to 'absolute joy'). On average the overall experience was positive (average: 3.6, standard deviation: 0.91). 64% made a joyful experience with the unit, for 12% it was even absolute joy.). Those 12% are all male users between 40 and 60 years old.

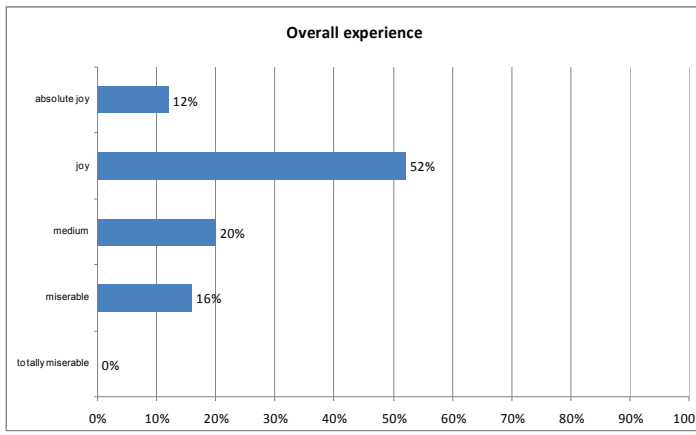

Figure 5 - Overall Experience made with the Electric-powered Personal Transportation Unit

No one made totally miserable experience with the unit, but 16% reported a rather miserable experience. Demographic data cannot explain which people are likely to make a joyful experience and which are not. However, all participants who made an absolutely joyful experience perceived the Electric-powered Personal Transportation Unit as very easy to ride (also cp. **Figure 3. Perceived easiness of riding**) and absolutely reliable (also cp. **Figure 1 - Perceived Reliability**).

4. CONCLUSION AND RECOMMENDATIONS

An electric-powered personal transportation unit has a lot of potential and could become a serious alternative for personal transportation. However, the unit's impact depends on a couple of conditions: Electric-powered personal transportation unit's role in urban mobility is currently restricted by a missing infrastructure. The unit would have a greater chance as alternative commuting device if there would be appropriate lanes in the streets, dedicated parking places, special parking places at train station (park and ride), and installations and equipment in trains to lift the vehicle into the train and to store it there.

Another drawback is the traffic regulations. Those regulations are commonly blamed to minimize the units' impact and to hinder innovation in personal transportation. The classification of unit being provided for the study does not seem reasonable: Either the unit should be allowed to be used on cycle lanes and sidewalks or the unit should be allowed to run faster (at least 20 km/h).

It is assumed that the unit will have more impact the more the vehicle itself plus its features will be change: The preferred speed ranges from 25km/h to 40km/h. Many participants wanted to ride the unit at about 30km/h as this is the speed they are used from small motorbikes, scooters and the like.

Participants offered a great deal of positive judgments. Most participants found it very easy to ride the unit. They praised the very short time needed to learn to ride it, the easiness of balancing and the intuitive way of riding the vehicle. The unit was perceived as very reliable and the handling of the unit seems to be perfectly convenient as long as it does not need to be carried, or mounted.

Most participants experienced situations, in which the electric-powered personal transportation unit was particularly convenient. Participants appreciate the increased flexibility and spontaneity as they do not have to stick to trains or tram schedules. They consider the electric-powered personal transportation unit as very convenient for short distances, enjoyed riding it uphill, and when seeking a parking place. They find it very useful to get around traffic jams. The overall experience was quite positive, the great outdoor feeling was widely appreciated, and many participants liked to have a share in contributing to the environment.

REFERENCES

[1] Veryzer W. R. and Borja de Mozota B. The impact of User-Oriented Design on New Product Development: an examination of fundamental relationships. Journal of Product Innovation Management, 2005, 22, 128-143.

[2] Lemasson P. and Magnusson R. P. Towards an understanding of user involvement contribution to the design of mobile telecommunications services. *In Proceedings of the 9th International Product Development Management Conference, Vol 2,* Sophia Antipolis, France, May 2002, pp. 497-511, published by the European Institute for Advanced Studies in Management and Ecole des Mines de Paris.

[3] Hartwick and Barki. Explaining the role of User Participation in Information System Use. *Management science,* 1994, pp. 440-465.

[4] Ives B. and Olson M. H. User involvement and miss success: a review of research. *Management Science,* 1984, 30(5), 586-603.

[5] Ulwick A.W. Turn customer input into innovation. *Havard Business Review*, January 2002, 92-97.

[6] McNeill K.L., Sanders T.H. and Civille G.V. Using focus group to develop a quantitative consumer questionnaire for peanut butter. *Journal of Sensory Studies*, 2000, 15, 163-178.

[7] Von Hippel E. and Katz R. Shifting innovation to users via toolkits. Management Science, 2002, 48(7), 821-833.

[8] Christensen G.L. and Olson J.C. Mapping consumer's mental models with ZMET. *Psychology & Marketing*, 2002, 19(6), 477-502.

[9] Keates, S., Clarkson, J. Countering design exclusion: an introduction to inclusive design, Springer Edition, 2004, pp.109-123.

[10] Ulrich, K. Estimating the technology frontier for personal electric vehicles. Transportation Research Part C 13, 2005, pp. 448-462.

[11] Litman, T. Managing Personal Mobility Devices (PMDs) on none motorized Facilities. Transportation Research Board Annual Meeting, Washington DC, January 2004.

Dr. Nadia Jamali
Swiss Federal Institute of Technology Zurich
Technology and Innovation Management
Kreuzplatz 5
8032 Zurich
Switzerland
+41 44 632 0583
njamali@ethz.ch