Customer requirements for a multitrack electric bicycle

Product development process for multitrack electric bicycles

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***Abstract*— In this study, an internet-based questionnaire was developed to make the customer requirements for a multitrack electric bicycle tangible. Participants also answered questions about future driving behavior with a multitrack electric bicycle, in comparison to their current driving habits with a conventional bicycle. Thus, this study provides information about critical features which are crucial for the acceptance of a vehicle concept on the market. The survey results significantly influenced the design and development of the vehicle concept "QuadRad".**

Keywords—Customer requirements, electric bicycle, product development process, survey, driving habits, QuadRad

I. Introduction

Sales of e-bikes have tripled in Germany since 2009 [1]. Electric bicycles are increasingly used as an alternative to the passenger car in everyday life. Electrified cargo bikes and multitrack vehicle concepts with electric support for the driver, such as the QuadRad [2], increase everyday usability [3]. In addition to industrial applications, these vehicle concepts are also used by private individuals in everyday life. In comparison to conventional bicycles, the design and construction of multitrack electric bicycles in particular are much more complex: The components of the electric drive train as well as the frame structure and the chassis. In the bicycle industry, there is no standardized product development process for such vehicle concepts. Based on process models from the automotive sector, a product development process (PEP) for multitrack electric bicycles will be developed, using the example "QuadRad". This process is divided into different phases. First, the actual condition is analyzed, including market environment and environmental impact, as well as legal regulations. In the next step, the target condition is defined. The focus is on the customer requirements for a vehicle concept. For design and evaluation of the vehicle concept profitability, driving dynamics, safety and luxury are adopted as evaluation criteria from the automotive industry. In addition, everyday usability, riding experience and ride comfort are considered.

An extensive planning and definition phase follows. After assembling a first prototype, during the implementation phase, testing and road tests, similar to the standard tests in the automotive sector, have to be performed. Before SOP (start of production) a field trial with potential users has to be conducted in order to cover and validate customer requirements. The integration of potential customers during the product development phase increases user acceptance and customer satisfaction when using the vehicle.

II. Procedure

A. *Research questions*

A survey of customer needs on multitrack electric vehicles was performed in order to investigate, how customer requirements can influence the design of a vehicle. The following items were the subject of the investigation:

- Criteria that impact the purchase decision for multitrack electric bicycles
    - Cargo area
    - Weather protection
    - Range
    - Ergonomics
- Applicability of the results for designing a vehicle concept

B. *Participants*

In the survey a total of 49 people participated, the average age is 45 years (SD = 14). Respondents are quite familiar with cycling. Apart from one, all participants own a conventional bicycle. However, only 14% of them own a so-called ‘pedelec’ (pedal electric cycle). Around 41% use the bicycle in their free time as sports equipment. On average, they ride four hours by bike (SD = 2.66) per week.

C. *Customer requirements for a multitrack electric bicycle*

In this study, an internet-based questionnaire with 54 questions was developed. Four main topics were created:

- Demographics
- Current driving habits by bike
- Requirements for a multitrack electric bike
- Impact on future driving behavior with an electric bicycle

The questionnaire incorporates mainly questions with answers, in which the respondents had the opportunity to supplement their answers with comments. The use of closed questions increases the objectivity of the survey and facilitates the interpretation of results. In an open question, the survey participants had the opportunity to describe their "perfect bike". The aim of this open question was to obtain qualitative information on the ideals of a vehicle concept of the interviewees, without affecting this by specifications.

The questionnaire was presented on the website of the model community for electro mobility, short e-GAP. Thus, interested individuals were addressed who are familiar with electro mobility and similar vehicle concepts. This type of survey made it possible to collect data from people from a large geographical area. In a period of about four weeks, 49 people completed the questionnaire. This relatively small sample size may have been caused by the placement of the questionnaire on the website. In addition, some questionnaires were incomplete and could not be included in the evaluation.

The analysis of the questionnaire is limited to the descriptive analysis. In addition to that, the results are plotted. Comments and also the open question are evaluated by means of a quantitative content analysis.

III. RESULTS

The results provide insight into the current riding habits of the interviewees as well as into the requirements for a new vehicle concept and the impact on future handling. Moreover, by using the results, the concept of a multitrack electric bicycle was substantiated. When answering the questions multiple answers were possible, the participants also had the chance to abstain. Consequentially, the sum of the responses for each question is not always congruent with the sample size.

A. Demographics

The interviewees have an average age of 45 (SD = 14), the youngest participant is 19 and the oldest is 78 years old. 87% of the respondents consider themselves to be at an average level of training or as ambitious recreational athletes, only 13% stated that they were untrained. It follows in relation to the frame geometry that the riding position may be quite sporty and a particularly low access is not strictly necessary.

The mean body height and age of the respondents, derived from the demographic data, require necessary adjustments to the frame geometry and ergonomics. If a bicycle is used by different individuals, the development engineer has to ensure adjustability. An important tool for the ergonomic design of products is the use of percentiles. In relation to the body size, the percentile indicates, for example, what percentage of people in a population is smaller than the specified value. Furthermore, one can distinguish between the percentiles of male and female persons. Whenever possible, products are generally designed so that they can be used in a range from the 5th percentile female to the 95th percentile male. Consequently 95% of the population is theoretically considered [4]. The 5th percentile female corresponds to a height of 1535 mm, the 95th percentile male corresponds to a body height of 1855 mm [5]. In addition to that, the data gained from the survey was compared to this method. The average height of the male respondents is 1809 mm and the body height of the female interviewees is 1535 mm. These results verify the design of the vehicle concept based on percentiles. This is a highly relevant topic for the development of a bicycle, particularly with regard to ergonomic seating position. The seating position has an influence on riding comfort and behavior, as well as the power transmission respectively the riding performance. Seat comfort is influenced by load spreading and the center of gravity of the rider. The arrangement of the saddle, pedals and handlebars is critical for a convenient and, with respect to the power transmission, effective seating position [6]. Especially with bicycles, a proper seating position is essential. On the one hand, a bicycle that is too small for the rider can easily lead to joint and back pain. On the other hand, if a bicycle is too big it can be a safety risk for the rider and other road users. Particularly when riding a bicycle with diamond-frame geometry, one has to ensure that the frame is not too big. For rental or cargo bikes, one should aim to find a frame geometry which is appropriate for as many people as possible. However, it is impossible to develop a bicycle which is appropriate for everyone.

B. *Current driving habits by bike*

Survey participants are individuals who use the bicycle in everyday life or leisure. In addition to everyday use, approximately just over half of them use the bicycle for training purposes as piece of sports equipment (Fig. 1). In many cases, these people own two or more bicycles for different purposes.

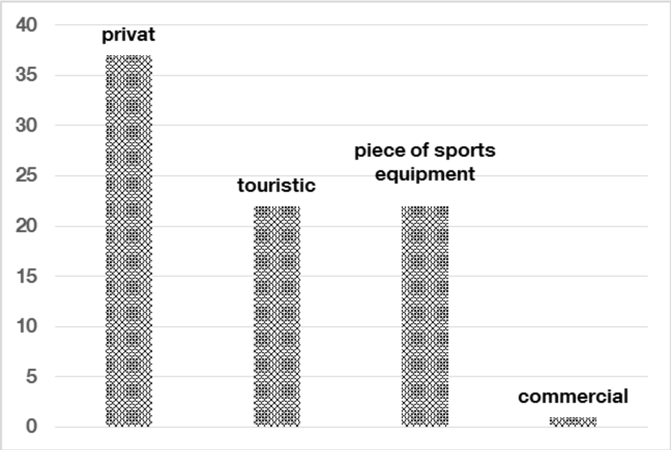

Fig. 1. Intended use of bicycle

Three quarters of the survey participants have a bicycle that is compliant with the StVZO. Hence, these bikes have a prescribed lighting, bell etc. and are mostly equipped with mudguards by manufacturers. Surprisingly, only one third of the bicycles are provided with a basket at the front or rear of the bike. According to the survey, most people carry a bag or daypack and small purchases for daily needs. A conventional carrier is usually for 25 kg special models designed for a maximum of 40 kg payload. However, a bicycle with high load of weight on the carrier is quickly unstable and thus difficult to handle for the rider.

On average 8 km will be covered with the conventional bicycle a day; it is often used to transport daily purchases. The maximum daily mileage of an individual amounts to medial 24 km. Other studies have shown that the kilometers' traveled with a conventional bicycle as well as with a pedelec average out at 47 km per week [3]. This supports our own survey results. These and other results allow conclusions on the necessary battery and transportation capacity relating to the interpretation of a multitrack electric bicycle. Moreover so-called secondary effects must be taken into account, both battery and transport capacity have an influence on the total weight of the vehicle concept and the suspension design. However, the actual required battery capacity for motor assistance differs from the desired range of the driver. If the battery level is equal to or even lower than conventional pedelecs, this could cause uncertainty among riders although there are no bottlenecks. The battery consumption is highly dependent on the actual support level of the electric assistance and distance profile [7]. Beside these characteristics, the tire pressure and gear changing have influence on energy consumption. In summary, one can say, that the range predominantly depends on the vehicle characteristics and the rider respectively his riding behavior (Fig. 2).

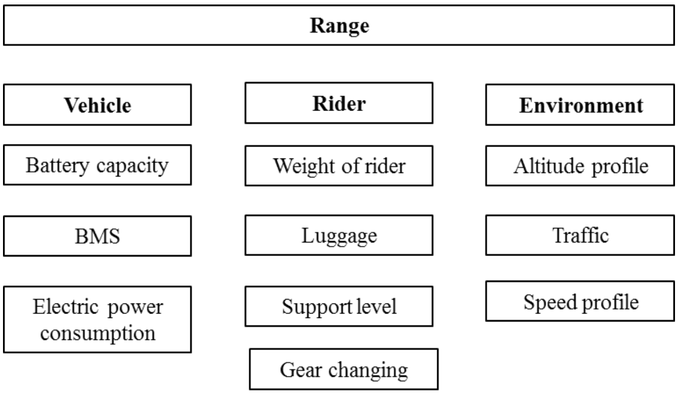

Fig. 2. Characteristics influencing range of electrical assistance

Participants indicate that they mainly ride a bike on flat roads or low pitches. Only a small percentage uses the bicycle to also overcome steep inclines (Fig. 3). These facts speak for themselves against disproportionately high battery consumption. In relation to ergonomics, the use of the vehicle concept in everyday life on mostly flat roads is relating for a comfortable sitting position similar to a touring cycle. Characteristic for this seating position is an even distribution of force on the handlebar, saddle and pedals. The upper body is slightly inclined and the spinal column takes a so called s-shape. [6]

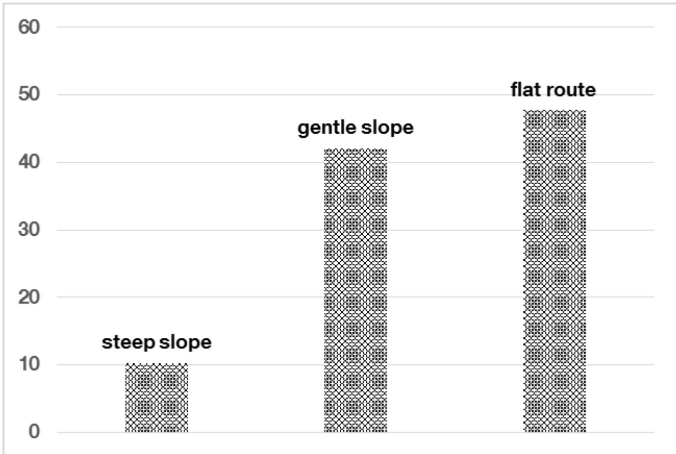

Fig. 3. Distance profile

Three quarters of the respondents indicated that they mainly used a bicycle for recreational purposes. 71% use the bicycle as a means of transportation and 69% ride a bike because they think that it is health enhancing. Most frequently it is used in order to ride to work, to friends or to the supermarket. For about half of the respondents, the bicycle is a piece of sports equipment (Fig. 4).

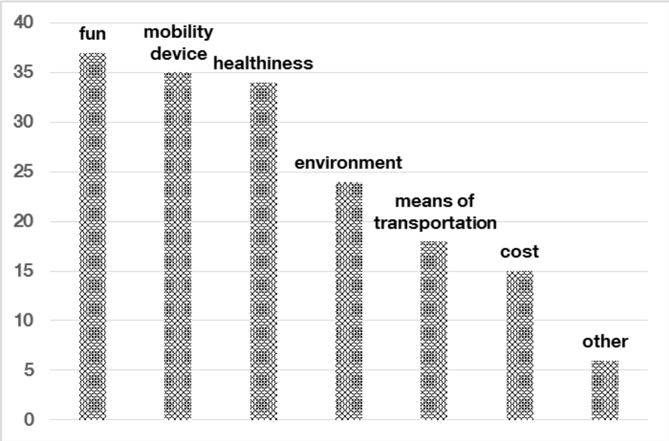

Fig. 4. Reason for riding a bicycle

The bicycle is mainly used during the day, only about one-eighth uses this kind of vehicle concept at night as a mobility device.

77% of the respondents make use of the bicycle at least once or twice a week; almost half of them use the bicycle daily (Fig. 5). These people usually go to work by bicycle.

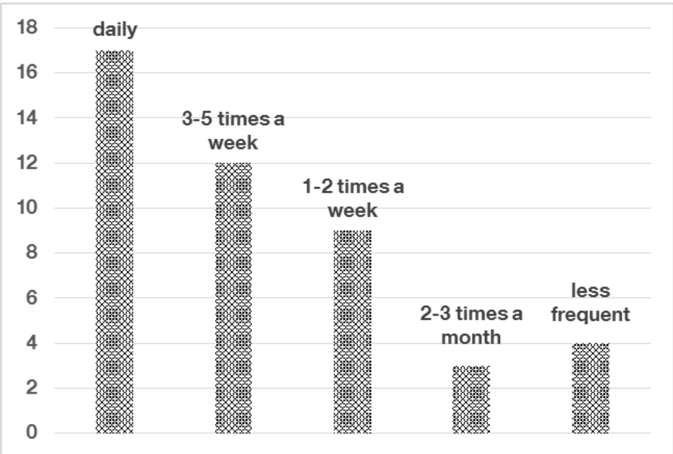

Fig. 5. Frequency of bicycle use

Nearly 90% use the bicycle in spring, summer and fall, whereas in winter they prefer alternative means of transportation. In addition to that, the statement supports that the use of a bicycle is dependent on the weather, for more than half of all respondents (Fig. 6).

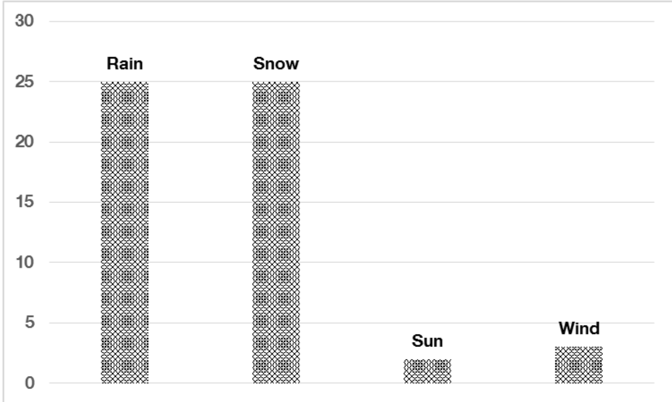

Fig. 6. Weather dependency of bicycle use

The majority abstain both in rain and in snow from riding a bicycle. However, weather protection is required only by a very small group of people. This implies that a concept vehicle would not make people change their cycling habits in bad weather conditions due to a vehicle concept. It is preferable to rely on a more comfortable means of transportation. The distances covered by normal bikes are mostly asphalted, or well-constructed forest roads. Forest trails and gravel roads are rarely frequented (Fig. 7). With respect to the chassis and the tires, one has to consider that a bicycle used for everyday life is mainly used in urban areas.

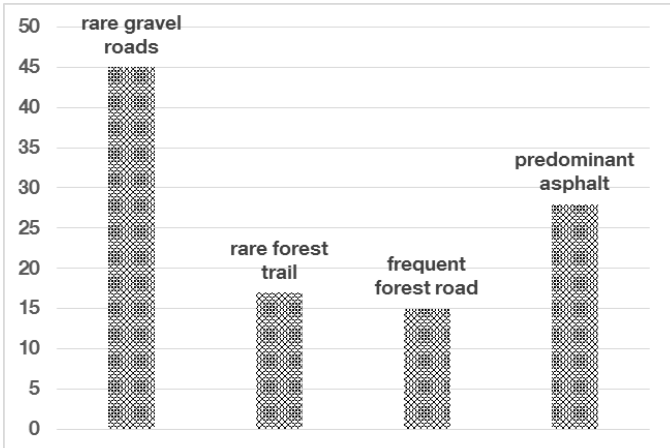

Fig. 7. Various surfaces when cycling

Thus, the chassis design can be chosen on the basis of this application. The chassis clearance must be adapted to obstacles in the road infrastructure. The term chassis clearance is defined as the shortest distance between the roadway surface and the lowest fixed point of the vehicle. Following guideline 92/53/EEC, the ramp angle is defined as the minimum acute angle between two levels perpendicular to the median longitudinal plane of the vehicle that are applied tangentially to the tires of the front or rear wheels, under a static load and touching the intersection of the rigid bottom part of the vehicle outside the wheels. The ramp angle defines the steepest ramp a vehicle can traverse [8]. According to our results, one can dispense with a high ground clearance.

C. *Impact on future driving behavior with an electric bicycle*

Compared to the results of the current driving habits it becomes clear that the individuals like to transport heavy and a great plenty of things by bicycle. This however is not the case in reality due to limited transportation capacity of a conventional bicycle. An appropriate vehicle concept, where one can carry all kinds of goods quite comfortably, without having stability problems, can change the driving behavior of people. To verify this hypothesis, a corresponding field trial is currently being conducted.

Most of the respondents have indicated that they want to transport lightweight goods, for instance purchases of daily necessities and heavier things like beverage crates. Furthermore, a child's safety system is desired. A few want to carry sports equipment, musical instruments or a toolbox. Thus there are special requirements for loading in terms of minimum capacity and payload.

Regarding riding habits, users are not willing to change them. However, they cannot imagine covering more kilometers daily. This result is congruent with surveys on electric bicycles [3]. Through the assistance of the electric engine, the physical stress on the driver is low, and thus the distance by bicycle could increase. On average, one could cover a distance of 8 km a day with a conventional bicycle without an electric motor. The riders may be willing to increase the daily distance by bicycle if they recognize that it is much more comfortable to travel by pedelec. Investigations have shown that the average speed is 2 km/h higher when traveling by pedelec instead of a conventional bicycle [3].

With an open question on what the perfect bicycle looks like and how it should be equipped, the study participants' ideal conceptions were queried.

- "Lightweight, comfortable seating position"
- "Practical for driver and child, license and big load"
- "Should have a loading platform and weather protection to use it to travel to and from work"
- "Stable bicycle with adequate cargo space"
- "Variable cargo space (lots of storage), open or closed and locked, sporty look (not applicable for older age groups), electric engine, small size ratio, appropriate price"
- "Smooth-running, easy to use, useful, theft-proof, transportable"
- "A full-featured touring bike for daily use, and a light as possible mountain bike for sports"
- "Easy to steer and colorful painted to ensure a good mood"
- "Fast, flexible, light, mountain-friendly"

The trend outlined in the quotations above, shows that the participants would like to have a bicycle equipped with a comfortable seating position and a cargo area. Moreover ride comfort and riding experience play a decisive role.

D. *Applicability of the results for designing a vehicle concept*

Considering the survey results, the vehicle concept QuadRad was developed, which is described in more detail below.

1) *Vehicle concept QuadRad*

The so called "QuadRad" is a type of bicycle with four wheels and pedal electric assistance. The vehicle concept is designed especially for commercial applications and for use in everyday life. The concept integrates high transport capacity, driving comfort and safety of larger vehicles like cars with high flexibility and low total costs of ownership of small vehicles like conventional bicycles. Therefore, this vehicle concept combines the advantages of both vehicle types and enlarges the usability of Light Electric Vehicles. [2]

TABLE I. TECHNICAL SPECIFICATIONS – CONCEPT – QUADRAD

Admission	Pedelec, no type approval
Overall length	< 2200 mm
Overall width	< 800 mm
Wheel base	1350 mm
Wheel track	730 mm
Tire size	26 or 24 inch

The vehicle concept is powered by a mid-engine with a power of 250 W and a maximum torque of 70 Nm. In addition to that, the driver is supported up to a speed of 25 km/h by the electric motor, thus the QuadRad does not require registration [9], [10].

TABLE II. TECHNICAL SPECIFICATIONS – ELECTRIC ENGINE – QUADRAD

Drive concept	Mid-engine (BLDC)
Performance	250 W
Torque	Max. 70 Nm
Maximum speed	25 km/h

The battery module consists of 96 Li-Ion cells of type 18650 with a voltage of 44.4 V and a capacity of 1.0 kWh. The maximum electric range is, under ideal conditions, about 90 km.

TABLE III. TECHNICAL SPECIFICATIONS – BATTERY MODULE

Type	Li-Ion (96 cells, 18650)
Capacity	1.0 kWh
Voltage	44.4 V
Weight	5 kg
Maximum range	90 km

Based on the survey results, the battery capacity may be less, because the weekly vehicle kilometers traveled amount to 50 km and that is significantly below the maximum range of the QuadRad battery. For acceptance reasons and due to different application scenarios, it was decided to favor a higher battery capacity.

Overall vehicle weight is 60 kg and the chassis is designed for an additional load of 180 kg. This is ensured by a double-wishbone suspension front and a rigid axle rear. Particularly for applications in everyday life a vehicle payload of 180 kg is not required. However, especially this vehicle concept is also designed for commercial applications for transporting loads.

Regarding the survey results it was decided not to design an all-terrain vehicle. Moreover, the front pitch of the spring is 80 mm (compression: 60 mm; rebounding 20 mm), and, on the rear axle the pitch is only 60 mm (compression: 40 mm; rebounding 20 mm), which is adequate for a vehicle that is used mainly in urban areas. Areas suitable for the QuadRad are urban environments and in rare cases, unpaved roads. As a result of the low sub-tube, the QuadRad has a chassis clearance of 153.5 mm and a ramp angle of 15.9 ° (Fig. 8). The QuadRad has no overhang and slope angle due to the vehicle concept.

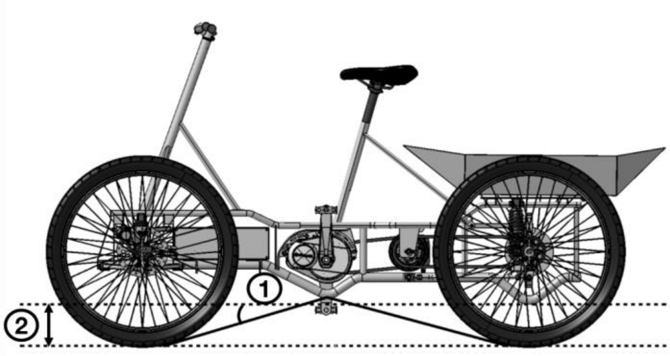

Fig. 8. Ramp angle and chassis clearance

On the basis of the results of the survey, for the concept vehicle QuadRad a cargo area with a size of approximately 820 mm x 575 mm in the rear of the vehicle, was designed. The frame has a modular design, thus the superstructure can be adapted individually to the customer’s needs or the intended use. The different requirements of respondents imply that an adjustment of the cargo area is inevitable.

Regarding the package, battery, BMS and vehicle control system are located at positions 3 and 4. To provide adequate transport capacity in the package, both the front (1) and rear (2) space for a transport case is provided (Fig. 9).

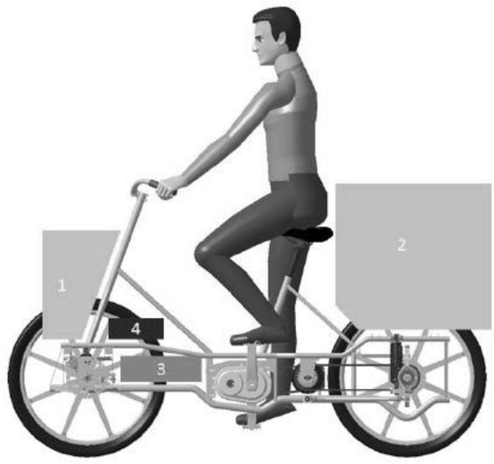

Fig. 9. Package – cargo area – vehicle control system – battery

The seating position on the QuadRad is comparable to a trekking bike. In addition to that, the seat angle from the rider amounts to 45°, depending on the stem and handlebar used. The driver has therefore a straight and comfortable seat position. Seat tube angle amounts to 74° and the steering tube angle amounts 70° (Fig. 10) what is comparable with conventional bicycle geometry of a hardtail bicycle [6].

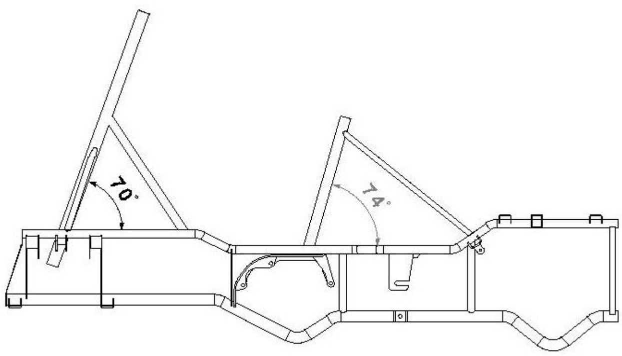

Fig. 10. Seat tube and steering tube angle

In the phase of development and dimensioning of the QuadRad, focus is placed on suitability for everyday use, the subjective riding experience, comfort and the safety of riders and other road users (Fig. 11). Riding dynamics, which is often suboptimal in conventional three-wheeled concepts, plays a major role.

The emphasis of the different areas has been determined by the development team.

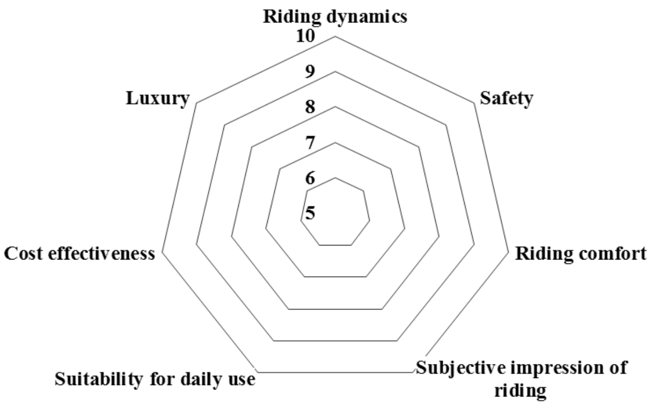

Fig. 11. Spider chart – design of multitrack light electric vehicles

In order to test and validate the QuadRad, internal testing is currently taking place. Different tests relating to riding dynamics have been developed that are derived from standard testing procedures of the automotive industry. Moreover, a road test is currently being performed wherein the vehicle concept is used in daily routines. Since April, a distance of 976 km was covered by the QuadRad (Fig. 12).

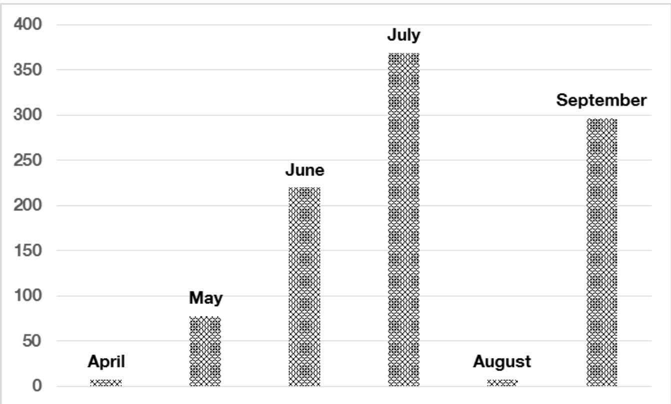

Fig. 12. Vehicle kilometres traveled - QuadRad

IV. DISCUSSION

The results are based on a sample of 49 people. Due to the relatively small sample size, represent merely a trend. The online survey was available on the website of the “model community for electro mobility” on the internet. The participants are mainly from the district of Garmisch-Partenkirchen or from Bavaria. Moreover, only private persons took part in the survey, no employers. To validate the survey, we recommend a nationwide repetition of the study with a larger number of study participants.

The use of cargo bikes promises benefits, especially in the commercial sector. In order to develop a vehicle concept for commercial applications, more interviews with an appropriate target group must be carried out. Taking transport capacity and range of the electric engine in account, the results of private persons who use the vehicle in everyday life represent minimum requirements. The literature reveals that, for instance, bicycle couriers with an electric cargo bike cover a maximum distance of 90 km a day [11].

The results of the survey have shown that private users, by their own account, cover a daily maximum distance of 24 km with their bicycle. Thus there is a difference, between commercial applications and private users, by a factor of 3.7. Depending on the application, it needs to be investigated in studies with volunteers, which range the customers want, regardless of the actual daily mileage. This prevents range anxiety and increases the acceptance of the vehicle. This is also enhanced by the early integration of potential customers in the product development process.

Only 14% of the study participants own an electric bicycle and can consequently judge the relief by the support of the electric engine. For the remaining group, it is much more difficult to assess future riding behavior with a multitrack electric bicycle. The benefits and the facilitation while pedaling with electric assistance are often underestimated. In particular, the transport of loads or goods with an electric bike in comparison with a conventional cargo bicycle is not a big issue. However there are stability problems with single track cargo bikes and it is sometimes difficult for the rider to keep balance. In addition, multitrack cargo bikes do not have stability problems caused by extra weight. A multitrack approach prevents stability problems caused by vehicle payload. A volunteer study is in progress to validate this hypothesis. This scientific study, compares the riding behavior of single- and multitrack cargo bike concepts by test persons. The presented feature chart for design of multitrack light electric vehicles (Fig. 11) is also filled in as part of this investigation.

The vehicle concept QuadRad will be extensively tested in a field trial with different riders over a long period. Following the field study, it will be possible to make a statement either confirming the results of the survey “Customer requirements for multitrack electric bikes”, or not.

V. CONCLUSION

Customer requirements for multitrack electric bicycles are the subject of this investigation. This involves the evaluation of decisive criteria which influence the buyer’s decision process for such vehicles. Those vehicle characteristics in turn have to be taken into consideration while developing a multitrack cargo bike. As part of an online survey, participants were asked about the following topics:

- Demographics
- Current driving habits by bike
- Requirements for a multitrack electric bike
- Impact on future driving behavior with an electric bicycle

In particular, requirements for the transport area, weather protection, range with electric assistance and ergonomics were queried.

Astonishing is the result that the respondents reject a weather protection, because this is particularly frequently desired by cyclists in order to be independent of the weather. However, the results clearly show that the majority is not willing to change their riding habits. In poor weather conditions they would rather rely on alternative vehicle concepts, which are much more comfortable. Private users state that they use the bicycle predominantly in everyday life as a mobility device. Most of the survey participants use it daily or several times a week. Cyclists generally tend to ride on flat roads or routes with only slight slope. From this, we can infer that\ the seat position must be convenient and comfortable, as opposed to a bicycle which is used as piece of sports equipment. The analysis of the respondents'current riding habits has revealed that the battery of the vehicle concept does not have to provide a particularly large capacity. The potential users predominantly cover short distances with a bike. Certainly, in connection with the range anxiety of customers a greater range of the vehicle with electrical assistance is often required than they actually need. In turn this has an impact on the acceptance of the vehicle concept.

The insights gained have been incorporated into the development of the vehicle concept QuadRad.

In conclusion, the integration of potential customers in the entire product development process for bicycles is recommended in order to increase the user acceptance of this kind of vehicles. The customer evaluates a vehicle concept in a different manner than a development engineer does.

Acknowledgment

This work was supported by the Bavarian Ministry of Economic Affairs and Media, Energy and Technology, within the joint research project QuadRad.

Contributions

Markus Lienkamp made an essential contribution to the conception of the research project. He revised the paper critically for important intellectual content. Mr. Lienkamp gave final approval of the version to be published and agrees to all aspects of the work. As a guarantor, he accepts responsibility for the overall integrity of the paper.

References

[1] Statista, Absatz von E-bikes in Deutschland, entsprechend des ZIV, 2015.

[2] S. Steinmaßl, K. Müller, M. Lienkamp, " QuadRad - Muscle-Electrically Powered Vehicles". 5th Colloquium of the Munich School of Engineering 2015 Proc. "Innovations for Energy Systems, Mobility, Buildings and Materials".

[3] K. Schleinitz, L. Franke-Bartholdt, T. Petzoldt, S. Schwanitz, T. Gehlert, M. Kühn, „Pedelec-Naturalisitc Cycling Study", Unfallforschung der Versicherer GDV, Forschungsbericht Nr. 27, August 2014.

[4] H. Bubb, K. Bengler, R. E. Grünen, M. Vollrath, Automobilergonomie. Springer Vieweg (ATZ / MTZ-Fachbuch)Wiesbaden, 2015

[5] DIN Deutsches Institut für Normung e.V.: Ergonomie – Körpermaße des Menschen – Teil 2: Werte. DIN 33402-2. Beuth Verlag, 2015.

[6] M. Gressmann, et al., Fachkunde Fahrradtechnik, 4. Auflage, Verlag Europa-Lehrmittel, Haan-Gruiten, 2011

[7] S. Weichhold, D. Kriesten, W. Kilian, U Heinkel, Energieoptimierung und Verbesserung der Reichweitenvorhersage für Pedelecs, In Entscheidungen beim Übergang in die Elektromobilität, H. Proff (Hrsg.), Springer Gabler, Wiesbaden, 2015.

[8] Richtlinie 92/53/EWG des Rates vom 18. Juni 1992 zur Änderung der Richtlinie 70/156/EWG zur Angleichung der Rechtsvorschriften der Mitgliedstaaten über die Betriebserlaubnis für Kraftfahrzeuge und Kraftfahrzeuganhänger. 92/53/EWG, 1992.

[9] STRAßENVERKEHRSGESETZ in der Fassung des Inkrafttretens vom 01.05.2014. Bundesgesetzblatt Jahrgang 2013 Teil I Nr. 52 S. 3313, Bonn, August 2013.

[10] RICHTLINIE 2002/24/EG DES EUROPÄISCHEN PARLAMENTS UND DES RATES vom 18. März 2002 über die Typgenehmigung für zweirädrige oder dreirädrige Kraftfahrzeuge und zur Aufhebung der Richtlinie 92/61/EWG des Rates.

[11] J. Gruber, A. Kihm, V. Ehrler, Innovationsbereitschaft von Fahrrad- und Autokurieren gegenüber Elektro-Lastenrädern – eine (ir)rationale Entscheidung? In: U. Clausen, C. Thaller, Wirtschaftsverkehr 2013, Springer, Berlin, 2013