Design Concept of the Future Electric Vehicle-society: Applications of a Multi-functional Modular Electric Vehicle MMEV and its Consequences on the Present and Future Road Net

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Abstract

The car of today is a concept of an internal combustion engine vehicle (ICEV) that is based upon merely the packaging of the engine that is expanded to the body structure of the vehicle. Applying fine electric vehicle (EV) technology a renewed car transportation is created to solve the problems of today's traffic jams, car accidents and transportation smog. A concept of a 'Modular Multi-functional Electric Vehicle (MMEV) is originated, which is a composed system design of 1, 3, 6 or 8 battery-modules of 600mm in width and 900mm in length. This concept innovates transportation over a time span of 5, 10 or 20 years applying four types of MMEVs: the MMEV-Chair, -Tatami, -Road and -Room. It makes it possible to climb staircases, to double the capacity of today's traffic or to offer space of 2,400mm in width for the weaker road user while keeping today's road capacity the same and to integrate indoor and outdoor use of a vehicle while managing time and making communication with people more easily. In this paper the development process is explained, concept sketches are proposed, models are made and verified and a real first running chassis of an MMEV-Tatami is realized to evaluate its size, floor base and hands-free driving mode.

Keywords

concept design, electric vehicle, modelling, prototype

1. INTRODUCTION

There is a serious problem with air pollution, energy consumption, traffic accidents, the clogging of roads and the car pile-ups that are caused by the car industry [Kondo et al., 1996]. The first two problems of the air pollution and energy consumption are partly solved by the development of the present electric and hybrid cars [Hornburg, 2001]. For the additional problems - car accidents and car pile-ups - an intelligent electric car concept, which can be built up in a modular mode of construction and can be used in a multiple, flexible way, is appropriate. By applying the original system technologies of the world's best achieving and advanced electric vehicle 'Keio Advanced Zero Emission Vehicle' (KAZ) [Shimizu et al., 2001; Gavine, 2001] on a multi-functional, intelligent and modular car concept the transport possibilities are expanded for everyone to no matter where at no matter what time. Thanks to EV-technolgy's miniaturized components its environment-friendly energy consumption [The Pollution-related Health Damage Compensation and Prevention Association, 1998], its highly efficient low power that is required for a high performance, its sustainable transportation system [Shimizu et al., 1996], its software oriented networks [Hashimoto et al., 2002] people, information and spaces can be brought closer to each other in one system design for car transportation.

In this paper the design concept of a 'Multi-functional Modular Electric Vehicle' (MMEV) is developed. The purpose and the development method of this multi-functional modular vehicle concept is described and its technological feasibility is made clear. Moreover the cost-effectiveness of the present road net is shown to double and the traffic safety to optimize. Next to that consequences of the renewing application techniques in the short and the long run are described.

2. PURPOSE OF THE MMEV-CONCEPT

Small and independent driving floor bottoms having become technologically feasible [Onishi et al., 2003; Kawakami et al., 2003; Hashimoto et al., 2003] the idea has arisen to design a 'Multi-functional Modular Electric Vehicle' giving transport possibilities tot different end users. A system oriented 'car concept' is subject of innovating thinking work where a modularly built form design makes different flexible application techniques possible. Next to that this concept needs the requirements of an environment-friendly, durable, energy-friendly and users-friendly product development. To reach its goal the concept MMEV is developed out of three principles of the 'Universal design' [Connell et al., 1997] in combination with the 'New-Pic' method of the integrated product development (IPO) [Baelus et al., 2001].

3. DEVELOPMENT METHOD OF THE MMEV-CONCEPT

Because a conventional 'car concept' is primarily developed according to an object oriented development process [Gogh et al., 2004] and is shaped most of all as a kind of box on four wheels with limited flexibility in usage (like the terrain car, the sports car, the family car, etc.) the principles of the 'Universal Design' in combination with the 'New-Pic' method of the integral product development (IPO) offer the ideal development process to reach a system oriented car concept.

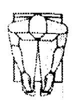
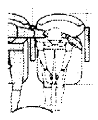
The first principle of the 'UD' forces the designer to make use as much as possible of identical components during the construction of the concept. As a matter of consequence the MMEV is chosen for every concept of electric vehicle starting from a multiple of battery modules that are made adjustable to greater entities.

The second principle of UD stimulates the design to use the human body as reference for developing a basis component. To reach the purpose of the MMEV the first principle is brought together with the second in an integrated way. As mentioned in 'Human Dimension' [Panero et al., 1979] the seat width is available between 254mm and 305mm and the seat depth between 686mm and 762mm. As a consequence the smallest inner room for the seat width of an MMEV can be assumed at 400mm and the seat depth at 800mm.

Taking into account the structure of a vehicle and the space needed for the covering the external space of the smallest MMEV can measure 600mm width by 900mm length as shown in Table 1.

If the smallest MMEV module measures 600mm in width by 900mm in length a single person can take place in the so called MMEV-Chair. Taking into account the combination possibilities of different modules the MMEV-Tatami is for instance composed out of three separate battery modules to a total score of 1,800mm length by 900mm width. If an even larger type is acquired, this is constructed with 8 battery modules that compose a vehicle with a size of 2,400mm length and 1,800mm width. Because of the wider size this type is named for instance

Table 1 Measurements of man in connection with the vehicle

	human dimension (mm)	EV – inner dimension (mm)	EV – outer dimension (mm)
 seat width (= Sw)	254 ~305	400	600
 seat depth (= Sd)	686 ~762	800	900

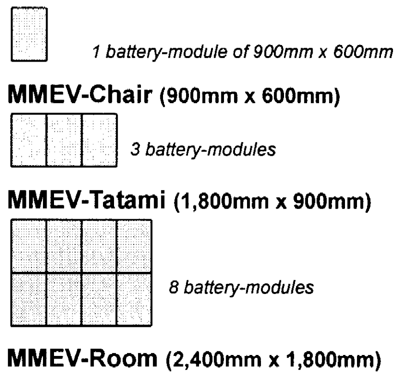


Fig. 1 Modular battery-composition of three EV types

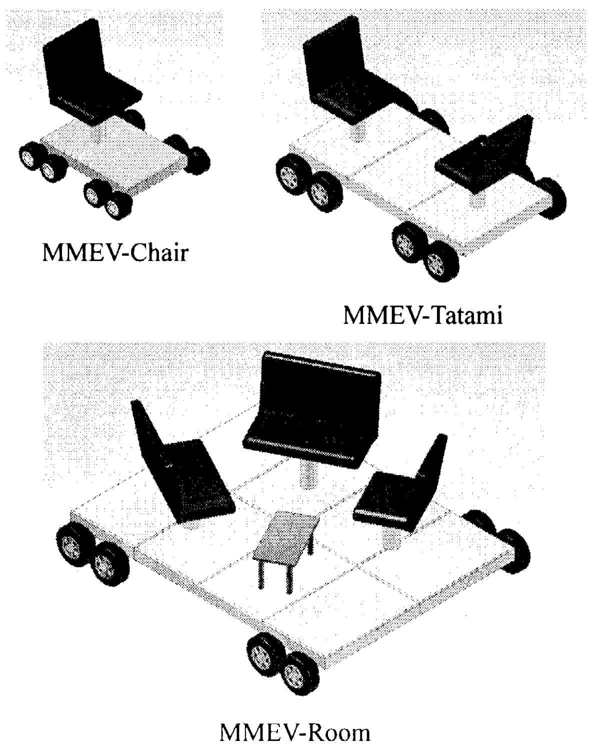
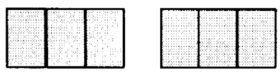


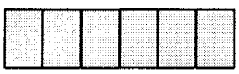
Fig. 2 Modular design of MMEVs

MMEV-Room. Thus three types come into existence: the MMEV-Chair, the MMEV-Tatami and the MMEV-Room as shown in Figure 1. These constructions have as consequence that new applications can be devised, each time in function of a multiple of battery modules. As a result of such a construction cabin rooms can be flexibly put on top of battery floors as shown in Figure 2.

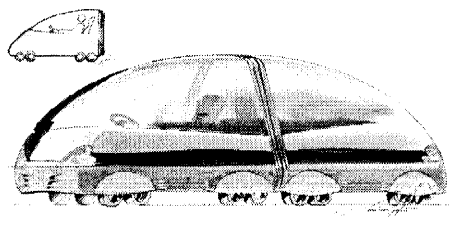
The third principle of UD forces the designer to see to a high flexibility in usage. For the MMEV-concept every battery module is as consequence seen as a flat floor bottom that can be smoothly put together and to which wheels are attached according to requirements. As a matter of consequence innumerably many combination possibilities arise. In figure 3a an example is given of an MMEV-concept that exists out of 2 separately composed MMEV-Tatamis that can drive separately. Figure 3b illustrates an MMEV-concept that consists out of connected MMEV-Tatamis, which make one unity with one roofed over users cabin, also named 'Double MMEV-Tatami'. The form design of such modular 'Double MMEV-Tatami' allows to provide a modular and multi-functional form design with which the vehicle can reach to a high adjustability and flexibility in usage, as visualized in Figure 3 C.



a. Two independent types of MMEV-Tatami
(2 vehicles of 1,800mm in length x 900mm in width)



b. One type of a 'Double MMEV-Tatami'
(1 vehicle of 3,600mm in length x 900mm in width)



c. Design of a 'Double MMEV-Tatami'
(1 vehicle design of 3,600mm in length x 900mm in width)

Fig. 3 Flexible approach of a 'Double MMEV-Tatami'

4. TECHNOLOGICAL FEASIBILITY OF THE MMEV-CONCEPT

4.1 Applied EV-technology

To put the MMEV Concept realistically in execution three recent electro technologies are put into practice: the 'In Wheel Drive System', the 'Component Built-in Frame' and the 'Tandem Suspension System' [Shimizu et al., 2001].

First there is the 'In Wheel Drive System' (IWDS) that neglects the engine room and its transmissions, because it integrates the energy system, motor, gear and brake. Thanks to its combined system it has high efficiency, light weight and increases the space of the cabin.

Secondly there is the 'Component Built-in Frame' (CBF) where all li-ion batteries and components are inserted into the structure under the floor that makes the space wider in the cabin, offers a lighter weight because the frame structure can be used for the battery case and offers in all a lower centre of gravity. The energy storage is on the batteries under the floor and a wheel axle can be installed anywhere on this 'CBF', so that it offers a different concept design of chassis and a highly flexible styling design.

Thirdly there is the 'Tandem Wheel Suspension System' (TWSS) that spreads the load over two smaller wheels instead of over one wheel. Taking into account those miniaturized technological components, not only an MMEV-system architecture for a high performance vehicle concept can be found, like it is realized in the KAZ [Gogh et al., 2003], but a completely modular multi-purpose electric vehicle can be achieved and made real thanks to the above-mentioned technological structure.

4.2 Features of the concept of an 'MMEV' body structure

Each car structure is built upon the 'CBF' that is shaped as one platform of a thickness of 130mm. That makes the chassis mechanically robust and stronger than the chassis of the 'ICEV'. Besides the centre of gravity is the lowest when li-ion batteries load the 'CBF'. Slip is limited and it offers a stable drive. For this reason a fully flat platform is required as a base on each type of an MMEV. This principle is shown in Figure 4.

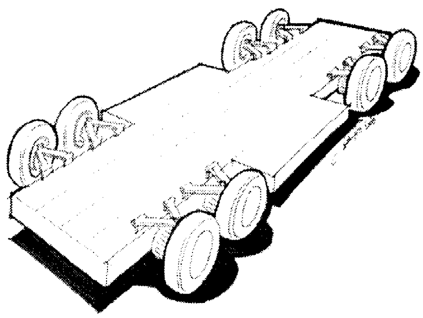


Fig. 4 Principle of a floor base of an MMEV-module

On a conventional chassis of an automobile two tires are installed on one and the same axle, which makes a total of 4 tires on a normal internal combustion vehicle.

On an MMEV it is required to use double wheel application, which makes a total of 8 axles on a standard electric vehicle. The reason for this 'Tandem Wheel Suspension System' (TWSS) is so as to offer a wider space in the cabin. Moreover this innovation offers an optimal vibration, low noise and a high grip while cornering, as already applied in the KAZ-concept [Onishi et al., 2003]. Similar to the technology-based floor design, which is used on KAZ, an MMEV-module can be realized being smaller than the original KAZ at the same time.

4.3 Composition of three MMEV-vehicle types

Taking into account the very many possibilities to put together the modular and multi-functional electric vehicle concept the technical power of the vehicles MMEV-Chair, MMEV-Tatami, and MMEV-Room is investigated first of all. A person who transports himself corresponds with an MMEV-Chair. Where 2 possibly 3 persons can take place or where a single person can have an ample luxury zone at his disposal an MMEV-Tatami corresponds and for 4 to 8 persons an MMEV-Room corresponds. Taking into account the above mentioned EV-technology the structure oriented demands and the amount of persons that momentarily take place in present cars three types can be created and compared to each other as specified in Table 2.

Table 2 Specification of three MMEV-types

	MMEV-Chair	MMEV-Tatami	MMEV-Room
passengers	single	single to 3 persons	family up to 4 ~ 6 persons
sizes	width: 600mm length: 900mm height: 1,500mm	width: 900mm length: 1,800mm height: 1,500mm	width: 1,800mm length: 2,400mm height: 1,700mm
max. speed	120 km/h	120 km/h	120 km/h
max. range	400 km / charge	400 km/ charge	400 km/ charge
connection	side by side and in the front and at the back	in the front and at the back up to 2 vehicles	in the front and at the back, up to 4 vehicles
style of use	daily work, shopping,	transit from work to the home, short meetings	gathering friends, holiday time, temporary visits on a location
running places	inside a house or buildings	inside buildings and on the road	on public spaces and on the road
0 – 100 km acceleration	10 sec	10 sec	10 sec
max power	18 kW	27 kW	45 kW

At first there is the MMEV-Chair, named after its one single person sized measurement on a length of 900mm and width of 600mm. It transports single persons inside a home. Those MMEV-Chairs are easy to attach one to another connecting them side-by-side as well as in the front and at the back thanks to the miniaturized electric vehicle components and a simple structure of body design.

Secondly an MMEV-Tatami is a vehicle measured 1,800mm in length and 900mm in width, of which the name 'Tatami' is lent from the Japanese standard of a 'Tatami' inside a home. It can transport people inside buildings and on the road. As soon as there is more than one MMEV-Tatami on the road, it can be connected in the front and at the back if requested.

Thirdly there is the MMEV-Room named after its basic function of a living room of 2,400mm length by 1,200mm width and usable by 4 to 8 persons who can be driven on the public road as well as on wide public spaces. Each MMEV-type has a maximum speed of 120km/h, acceleration from zero to 100 meter in 10 seconds and a maximum range of 400km. The parts of the inner space are all modularly designed in view of setting up removable chairs, small tables and small interfaces offering a single relax seat, a bedroom or a meeting room.

5. RELATION BETWEEN THE MMEV-CONCEPT AND THE ROAD SURFACE

5.1 Creation of the concept of an MMEV-road

As today's road infrastructure in urban and local areas cannot change quickly, a layout for an MMEV-type must be found that can easily be integrated on the actual residential road of 6m and 7m width [Heel et al., 2004; Western Australian Planning Commission, 1998], as shown in Figure 5. By using the above-mentioned modular approach of composing an MMEV-type by connect-

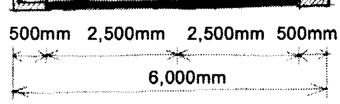
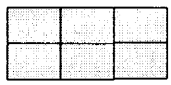


Fig. 5 Actual capacity of vehicles in the road of today



6 battery-modules of 900mm x 600mm

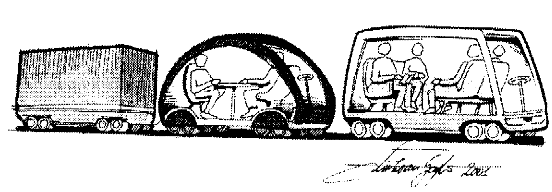
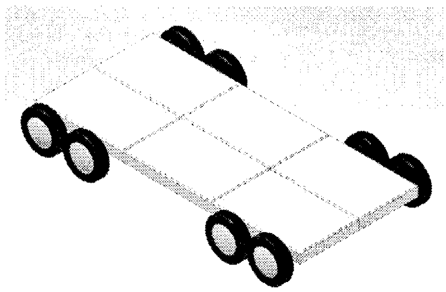
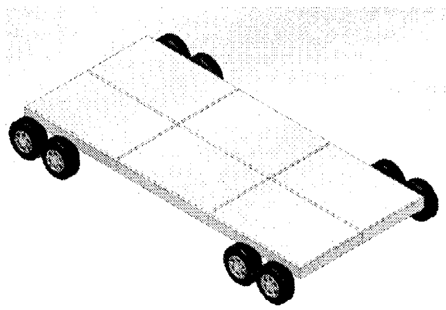


Fig. 6 Different new designs of the MMEV-road

ing battery-modules at the side of the battery's length or at the side of the battery's width an MMEV-Road can be composed on a width of respectively 1,200mm, a length of 2,700mm and a height of 1,700mm. Such an MMEV-Road is built by 6 battery-modules and can be designed for cargo transportation as well as for personal transportation, as illustrated in Figure 6.
Thanks to the modularly constructed chassis and the 'IWDS' the type and size of wheels that is applied to the chassis can be selected independently. Figure 7 A shows a vehicle with wheels of 400mm diameter and figure 7b shows a vehicle with wheels of 300mm diameter on one and the same chassis. This makes different designs possible.



a. (1,200mm x 2,700mm)



b. (1,200mm x 2,700mm)

Fig. 7 One MMEV-Road with different wheels

5.2 Automatic driving system for MMEVs

An automatic driving mode substitutes the driver who independently operates the vehicle. As the operator is not a person anymore, but a computer directed by sensors and controllers, it offers a high flexibility for the passengers and consequently also for the general public. Most of all it socializes transportation: everybody can be driven on a vehicle anywhere and at any time. In effect MMEVs can be operated as a taxi, for instance when someone should be brought back to his home after a party. So even when public transportation stops, MMEVs are efficient substitutes. The vehicle obtains its position by camera, road markers, GPS etc. Moreover an MMEV commutes with the other vehicles, traffic lights are observed and the perception of pedestrians is guaranteed, as illustrated in Figure 8.

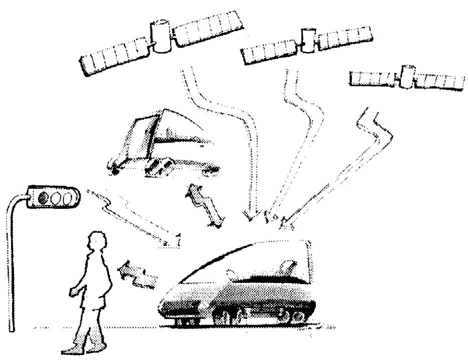


Fig. 8 Automatic driving system for each MMEV-type

5.3 Increasing the road capacity of today with the composition of the 'MMEV'-road

The 'MMEV-Road' vehicle type doubles the traffic capacity on today's road from 2 to 4 lanes because the actual standard width of one lane on a road is 2,500 to 3,000mm, which is made only for one standard gasoline vehicle of an average width of 1,800mm. An MMEV offers the possibility to bring 2 MMEVs of a width of 1,200mm on one and the same lane of 2,500 to 3,000mm width, which doubles the efficiency of transportation on today's roads. In view of reaching a more fluent traffic, the layout of the lanes on the road can easily be renewed without any change of the road-structure itself. Only the traffic lines on the road need to be repainted from 2 to 4 lanes thanks to the smaller size of the vehicles as illustrated in Figure 9. In the cities and urban areas there are not always lanes for the weaker road users at the side of the road. To reduce the risk of a traffic accident with pedestrians or people riding bicycles, 2 lanes for weaker road users should be foreseen including the size of 6000mm road space. Therefore 2 lanes are proposed at one and the same side of the road, or separately at the left or the right side of the road that is totally incorporated on the road's size, as shown in Figure 10.
In search of a high integration of a fluent traffic, a safe transportation, a low risk of traffic jam and taking into

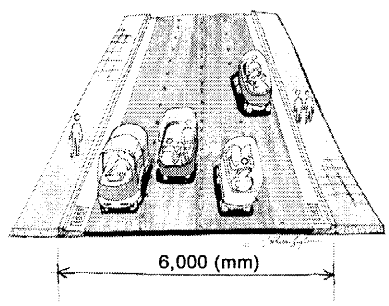


Fig. 9 Renewed layout of 4 lanes on today's road

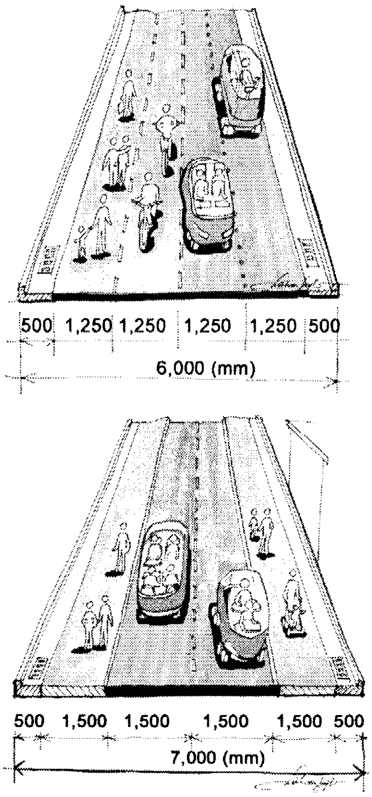


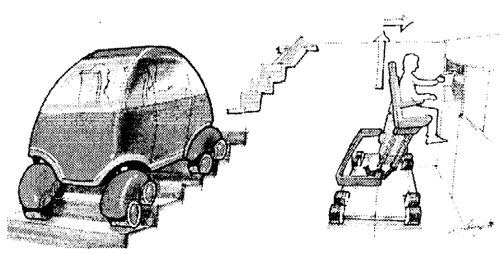
Fig. 10 Two incorporated lanes for weaker road users

account above mentioned MMEV-types of a width of 1,200mm an automatic driving system, invented by the EV lab of Keio University [Hashimoto et al., 2002] can be used in this proposed concept.

6. CONSEQUENCES OF THE MMEV-CONCEPT OVER 5 YEARS

6.1 'MMEV-staircase climbing'

An MMEV-Tatami' and an MMEV-Chair have a self-regulating 'Tandem Wheel Suspension System', which makes it possible to go up staircases. As the size of the wheels is 200mm and thanks to the independent controlled 'In-wheel Motor System' on each wheel, an MMEV can climb staircases and operate like a personal lift inside and outside buildings, as shown in Figure 11 A. The combination of a lowered centre of gravity and the tandem suspension helps to move the vehicle on up-going surfaces and to get easily on higher positions as shown in Figure 11 B. An MMEV puts forward the solution for retired and older people who have difficulties to climb staircases.



a) MMEV driving on a staircase position

b) MMEV reaching an elevated

Fig. 11 User's flexibility of an MMEV-concept

Additionally it is made feasible to reach an elevated position using the inner design equipment of an MMEV. When products on elevated cases must be reached, the seats on an MMEV can rise till the stored product to be taken. Moreover as the body structure is made simple and modular different inner designs can be made setting up a fully-customized MMEV-Tatami as illustrated on Figure 12.

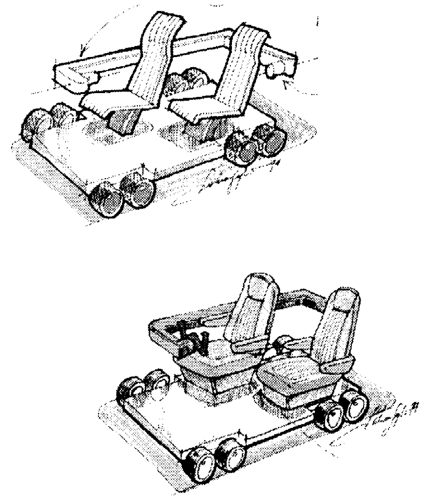


Fig. 12 Modular body structure of an MMEV

6.2 'MMEV-hospital'

Inside the hospital patients are lying on a bed for a long time and get isolated due to a medical problem for instance a broken leg so that the capacity to make contact with the outside world might decrease. Thanks to the integration of the medical electric devices on the vehicles MMEV-Chair and MMEV-Tatami a high mobility inside and outside the hospital is made possible, especially while patients have started their revalidation. As bedding equipment and personal mover have been combined on one and the same vehicle, even the oldest

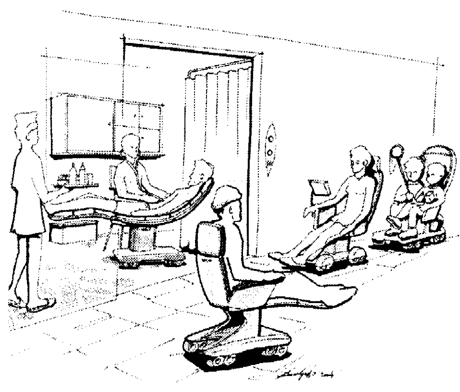


Fig. 13 An MMEV inside the hospital

persons can still keep their independence by driving anywhere they like as long as their body condition allows it. Pushing foreword this merit, the barrier between handicapped and non-handicapped people will disappear as shown in Figure 13. Healthy persons will use an MMEV to travel very quickly from one place to other. Persons who cannot go by themselves will use the MMEV-Hospital to keep their mobility inside and outside buildings.

6.3 'Gravity-mountain sport' by an MMEV

Car races of today are exciting thanks to their sound and the expression of the engine accessories on the outside. But using EV-technology entails that no noise, no vibration and no engine can be used to express an exciting car race anymore. Therefore a new type of exciting experience will be expressed by pushing the advantages of an electric vehicle (EV) to the limit, most of all robustness and stability. The low central gravitation point and the high grip of the wheels on the road surface keep the vehicle always stable, even on a slippery road. Consequently the new type of sport will push the EV's advantages to the limit. A flat horizontal infrastructure will go up to 90° vertically so that the stability of an MMEV cannot remain anymore. As an MMEV will fall down from the vertical up-going road to the horizontal road, the target of the new sport is to reach the highest level of vertical road surface.
For this reason and to be able to foresee exciting feelings for the driver during the operation, diverse unusual road surfaces can be built to provide exceptional driving conditions. A special mountain for example as shown in Figure 14 will offer a new type of exciting driving while the drivers fall down securely protected by their straps.

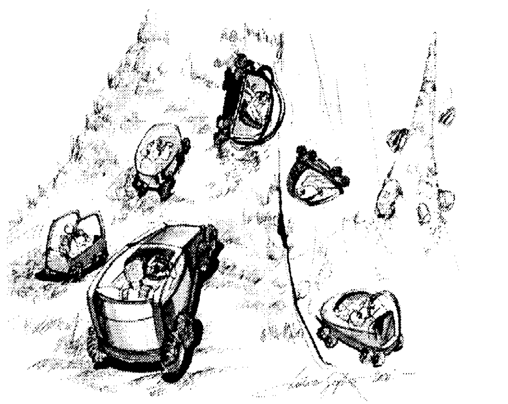


Fig. 14 'Gravity-Mountain Sporting' by MMEVs

7. CONSEQUENCES OF THE MMEV-CONCEPT OVER 10 YEARS

7.1 'MMEV-delivery cabin service'

The cabin of an MMEV can be made as an enclosed volume where modular equipment is built-in. Once the MMEV has arrived, the 'MMEV-Delivery Cabin Service' can operate as a temporary bar, cafe or small restaurant, where specific equipment can be exposed at the delivery place. It is helpful as an extended volume for example on birthday parties, company celebrations, lunch gardens etc. Such requested 'MMEV-Delivery Cabin Service' can drive automatically from one place to the other and it offers personalized service at the customer's demand.
For instance, as shown in Figure 15 A, an MMEV-Quick Cafe is equipped to offer a French "Cafe Bistro" in the garden of a home party. In transit the equipment and tools are roofed on the outside and it automatically drives to the delivery place. Once the vehicle has arrived, it robotically opens on the costumer's password. Inside the vehicle chairs open up so that the people may enter and sit down on the platform as illustrated in Figure 15 B. Drinks and foods are available inside and all visitors of the festivity can enjoy this new style of having parties on an MMEV.

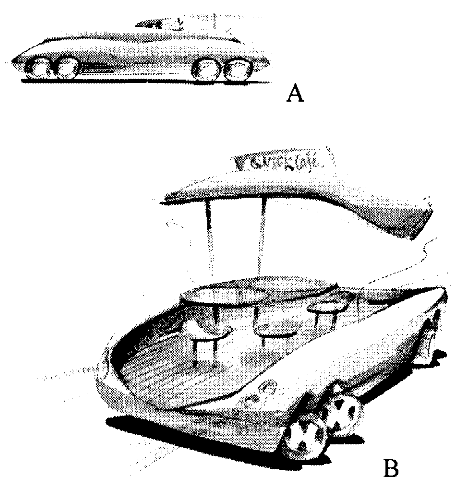


Fig. 15 'MMEV-quick cafe'

7.2 'MMEV-amusement cabin'

MMEVs are fully-customized vehicles because people can reshape them to apply them for an event in an amusement park. The design of the cabin of an event can easily be adapted to an MMEV so that a personalized EV can be used to enter an attraction. As a waiting line is long in most amusement parks before entering an attraction, this time can be used to adapt the inner and outer design of the vehicle to be fitted in an event so that the attraction can be maximally customized reaching a highly efficient exciting experience.
On a huge wheel for example, when people are afraid of a high elevation, an MMEV can be adapted to make the

passengers inside more comfortable by protecting them from the border of the vehicle. In this manner, each personalized MMEV can be integrated in the large wheel of amusement parks as can be seen in Figure 16.

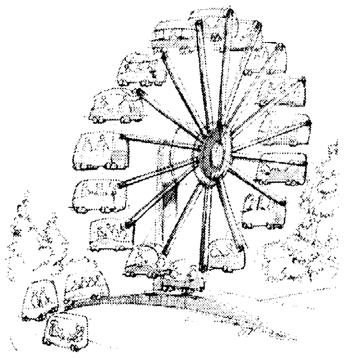


Fig. 16 An MMEV integrated in the large wheel of an amusement park

7.3 'MMEV-time manager'

The software on an MMEV allows time management for a single person driving an MMEV-Chair, as well as an estimate of the time needed by two or three persons each driving an MMEV-Tatami. When someone organizes a personal plan for the evening - for instance he wants to gather with his friends early in the evening and afterwards have a date with someone else on a certain place - a time schedule must be made for the evening.
Thanks to an MMEV time schedules can be programmed on the computer of the MMEV so that it operates as an alarm to remind the person of each event he wants to be in. In the situation when friends want to be in time for a concert, a movie theatre, a conference, a meeting or any kind of event that is planned after taking for instance a dinner, the risk of not being on time will be reduced with an electric vehicle thanks to an outside-controlled time manager.
In such a case the calculation of time on all MMEVs will make gathering vehicles possible just in time for the audience without delay. On top of this benefit a family, a single elderly person, a young couple, in short anyone can attend the audience thanks to the ability of an MMEV that brings persons to the place they want to be transported to as illustrated in Figure 17.

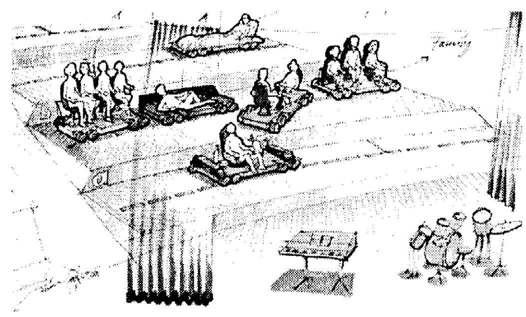


Fig. 17 Gathering on time for the audience without delay

8. CONSEQUENCES OF THE MMEV-CONCEPT OVER 20 YEARS

8.1 'MMEV-cargo'

Not only persons, but also goods are transported using MMEV-types. Depending on the size of the container, the platform of an MMEV-Chair, an MMEV-Tatami or an MMEV-Room can be used for transportation. Consequently as people and goods can be moved on the same area, an integrated mixture of trucks and passenger cars appears at one and the same road infrastructure, as shown in Figure 18.

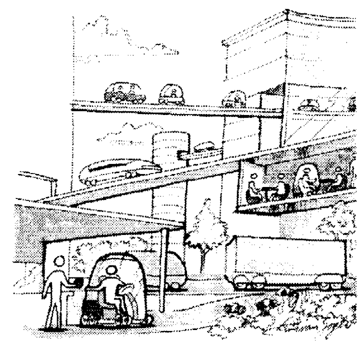


Fig. 18 Integrated traffic with a mixture of MMEV-types

8.2 'MMEV-indoor and -outdoor'

Taking into account above mentioned concept of the MMEV-types, the 'drive through' possibilities can be ameliorated to a fully indoor and outdoor driving.
As on a 'drive through shopping mall', selecting the type of food while shopping, gathering information about the preparation of some dishes, keeping cool frozen vegetables, storing some heavy goods on the transporters

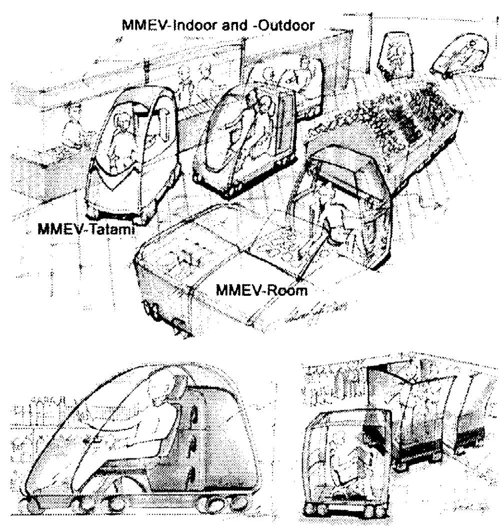


Fig. 19 MMEVs on a shopping mall

while shopping, it all can be applied on one and the same MMEV-'Indoor and -Outdoor'.
The food and the goods are presented by MMEVs built upon a chassis of an MMEV-Tatami or an MMEV-Room. This entails that space design and car design will be shaped more modularly so that a room or a building and the interior of a vehicle will attune to each other as illustrated in Figure 19.

8.3 'MMEV-contacting'

In public area, as for example inside and outside covered entrances of buildings, an MMEV enables people with similar interests to gather around one topic and have a meeting as shown in Figure 20. On a huge display in the middle of a public hall, topics are announced and depending on the interests of the people interactions can be made from one MMEV to other. Such topic may contain a workshop, a commercial or general presentation, a group discussion or a meeting. Networks among MMEVs can be set up and practical information about programming, timing, the frequency and the locations can be communicated. In this way using an MMEV helps to build up new contacts concerning similar personal interests and activities. Even the education system can be organized in a more flexible way.

9. EVALUATION OF PROPOSALS OF CONCEPT DESIGN

9.1 Realization of a model of an MMEV-tatami

Taking into account all above mentioned EV proposals, the most frequent application has been made possible using the type MMEV-Tatami. As Table 3 confirms four times (as 'Staircase Climbing', as 'Gravity Mountain Sport', as 'Time Manager' and as 'Cargo') the primary choice for the MMEV applications is an MMEV-Tatami. This model will be verified at first. Evaluating each concept the MMEV-Tatami is obviously first so that its fully flat floor base and its automatic driving system have been worked out first of all. Therefore a full sized scale simulation model of an MMEV-Tatami was made. As the function of an 'MMEV-Staircase Climbing' is obvious, the angle between the floor bottom and the horizon should be measured. As shown in Figure 21 the angle

Fig. 20 Meeting point of MMEVs on a public space

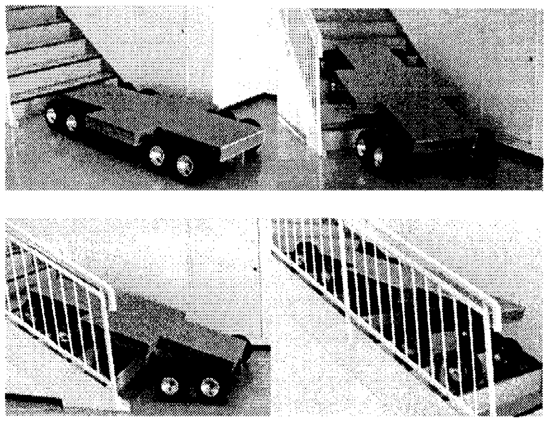


Fig. 21 Simulation model of an MMEV-Tatami

Table 3 Most frequent application: the 'MMEV-Tatami'

Time Span	'Future Applications	EV Chair	EV Tatami	EV Room
0-5 years	'MMEV-Staircase Climbing'	Feasible	**First Choice**	-
	'MMEV-Hospital'	**First Choice**	Feasible	-
	'MMEV-Gravity Mountain Sport'	Feasible	**First Choice**	-
5-10 years	'MMEV-Delivery Cabin Service'	Feasible	Feasible	**First Choice**
	'MMEV-Amusement Cabin'	Feasible	Feasible	-
	'MMEV-Time Manager'	Feasible	**First Choice**	Feasible
	'MMEV-Contacting'	**First Choice**	Feasible	-
10-20 years	'MMEV-Cargo'	Feasible	**First Choice**	Feasible
	'MMEV-Indoor and-Outdoor'	**First Choice**	Feasible	-
	'MMEV-Integration"	Feasible	Feasible	**First Choice**

of the vehicle changes between 0 and 35° so that the vehicle keeps stable while climbing staircases.
The size of one wheel on the tandem wheel suspension is 200mm, which is similar to the height of one single step on a staircase. This offers the opportunity to run up a staircase using an 'In-Wheel Motor System'.
Basic EV-technology is applied to an MMEV-Tatami and the size of a real running model measuring 900mm by 1,800mm is checked. As the 'Tandem Wheel Suspension System' is related to software oriented programming, a fully flat platform is generated to be able to apply to any type of cabin on the fully scaled structure of the chassis.

9.2 Test of the automatic driving mode

As future vehicle application is related to the automatic driving mode, the MMEV-Tatami running model has precise GPS sensors, CCD camera, Gyro-sensor and computer. The fully automatic driving is tested on a local area of Keio Electric Vehicle Laboratory of Shin-Kawasaki Town Campus as shown in Figure 22. Consequently the MMEV-Tatami reaches completely electrical and automatic transportation being our smallest tested MMEV at the same time.

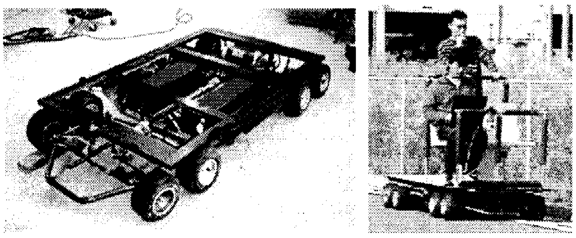


Fig. 22 Testing the MMEV-Tatami on the automatic driving mode

9.3 Integrating space and mobility by MMEVs

Based upon earlier mentioned potentials, which the EV-technology is offering to make an environment-friendly surrounding, the design of housing as well as the actual mobility can be changed. Clean ad silent vehicles can even be used as room inside a building, and the rooms inside a house can function as vehicles, thanks to the fully flat floor base that seems very similar to a floor base.
As illustrated in Figure 23 various types of rooms and vehicles are integrated in one and the same environmental design. The smallest untested MMEV is the MMEV-Chair that can easily be used for shopping and daily transportation inside and outside a house. As the size of an MMEV-Tatami is strongly comparable with the standard for the measurements of the houses in Japan, the same standardization is valuable so that the spaces harmonize

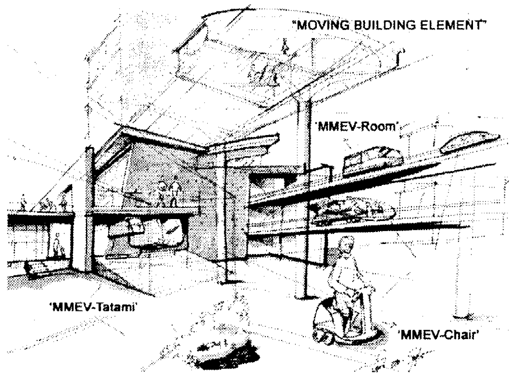


Fig. 23 Integrated environment with MMEV-types, spaces and mobility are harmonized

and create an optimal environment where people temporarily have their private and working site together.
On the left part of Figure 23, an MMEV-Tatami is installed behind an MMEV-Room and both are connected to the roof of the inner part of the building. Each MMEV-type can be selected by the costumer depending on the requested function.
Once the choice is made, an MMEV will be installed upon an integrated platform that is constructed by connected 'Component Built in Frame' (CBF) structures. Each running chassis, made by diverse sizes of CBFs, will be able to carry any type of user cabin. On the left part of Figure 23, the vehicle road is completely integrated into the design of a building which entails that the people may use their personal equipment inside a car because their car can be their office room at the same time. Two levels are placed the one upon the other where each road is divided depending on the sizes of the running 'MMEV-Integrated Platform.
The upper level is constructed to support the sizes of the 'MMEV-Tatami vehicle types' and the lower part is made to support the sizes of the 'MMEV-Room vehicle types'. On the top of Figure 23 a moving building element is imagined, where different chassises are integrated to one platform and the whole platform is moving from one side of the location to the other.

7. CONCLUSION

In search of a more efficient and environment-friendly car transportation, the most recent EV technologies are used to generate concepts for a future 'electric vehicle society'. The modular MMEV types: MMEV-Chair, -Tatami, -Room, and -Road have been created to replace today's vehicle park.
Using those MMEVs on today's road infrastructure the traffic capacity will be doubled, the traffic accidents will be reduced and a democratic transportation will bring people anywhere at any time and at any place.

It is shown that vehicles easily drive inside as well as outside the buildings and run on staircases inside and outside buildings. In addition, managing time, contacting people, 'gravity mountain sport', delivering services, and moving vehicles inside and outside hospitals has been designed with an MMEV.
As this ideation can start a future oriented view on transportation of people and goods, a full scale simulation of an MMEV-Tatami is constructed, a real automatic driving system is realized while tests show that these concepts can easily be put into reality over a time span of 5, 10 or 20 years.
By the production of an MMEV one contributes to the environmental impact, the system architecture of a vehicle as well as the modular approach to shrink components reducing the energy consumption at the same time. As such a really small MMEV with a high performance is acquired.
In this way vehicles will help to link people, goods and information so that the vehicle concept of today can be modified to a more environment-and human-friendly car transportation.

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