Most people, these days, live in automobile cities. Cars are essential for getting around; they mediate the experience of the city; they occupy huge amounts of real estate; they make a lot of noise and they clutter up the streets. Yet architects and urban designers mostly take them as given, and are content to design streets and public spaces around whatever the world's few remaining automobile manufacturers happen to provide. Here we challenge and reverse this well-worn assumption.

Transology: Reinventing The Wheel

trans ·ol ·o ·gy *Pronunciation: tran(t)s-'ä-l&-jE Function: nounInflected Form(s): plural -giesEtymology: Latin transportare, from trans- + -logie -logy*

1 : a field of design concerned with the interrelationship of mobility and the environment. 2 : the totality or pattern of relations between vehicles and their fundamental settings. 3 : the art of transfer or conveyance from one place to another by taking into account the surroundings.

Putting cities first

We begin with some ideas about the potential roles of personal movement systems in enhancing the human use and experience of the city, and we derive automobile designs from these. In other words, we design the car to suit a new vision of the city, not the city to suit the arbitrary specifications of the car.

Eliminating junk

The technologies that make this possible are those of miniaturized electronics, digital communications, inexpensive distributed computation, and advanced control software. They enable us to get rid of most of the junk that currently encumbers automobiles – engines, power trains, dashboards, and steering wheels. They allow us to define a fundamentally new, radically restructured architecture for the automobile.

Reinventing the wheel

The key move is to reinvent the wheel. We place a small but powerful electric motor, suspension, steering, and braking in each wheel. These robotic wheels have extremely simple mechanical connections to the automobile body, with just an electrical cable and a data cable going in. Each wheel operates autonomously and intelligently (like one of the horses attached to an old-fashioned carriage), and the motion of the wheels is controlled and coordinated by sophisticated software. Each can turn a full 360 degrees, allowing the car to turn at 90 degrees to park, to move crabwise, to spin on its own footprint, and so on. Through full-scale prototyping of robot wheels, and implementation of the necessary control software, we have demonstrated the feasibility of this concept.

Dancing with your ride

As surfboards and skateboards demonstrate, you don't have to control vehicles by means of cumbersome mechanical contrivances like steering wheels and pedals. You can do it simply be cleverly shifting your body – and it's a lot more fun. In our automobiles, electronic sensors detect the complex motions of the driver and software translates these into commands that control the robot wheels. The experience is not one of passively sitting in a soft seat and manipulating control devices, but one of dancing with your vehicle – which becomes an intelligently responsive partner.

Transology: *Changes to the body*

Softening the skin

Concentrating mechanical functions in the wheel provides extraordinary freedom to rethink the car body. Instead of taking the form of a rigid capsule made of dumb, spray-painted sheet metal (a very bad idea from an environmental perspective), it can consist of a structural exoskeleton combined with any skin material that provides a desirable combination of protection, display capabilities, sensing, and intelligent mediation between interior and exterior. In particular, the skins of our automobiles are mostly soft and flexible. When they rub up against each other, they don't scratch or dent – just as sheep in a flock can jostle without harm. This allows denser packing and gentler negotiation of routes in traffic streams and parking lots.

Articulating the body

The combination of omnidirectional wheel robots with a soft, flexible skin allows the body to be articulated, and to shift its shape and mass as necessary. It can have a skeleton, sinews, and pneumatic muscles. Instead of behaving like a brick on wheels, it can move like a well-coordinated dancer or skier. Our automobiles are articulated, muscled, soft-skinned shape-shifters that move with the grace of athletes.

Staying safe Traditional automobiles provide safety through a combination of safety cage, crumple zones, seat belts, and airbags – an unwieldy and unsatisfactory conglomeration of devices. Our cars provide it in the same way that a baseball catcher safely catches, in a flexible leather glove, a hard ball going at 90 m.p.h. – by employing intelligent motion to absorb impact, and by intelligently gripping – at just the right time and in just the right way – to provide restraint.

Transology: *Safety and Control*

Getting the most out of the least The usual way to make a fun automobile is to put excessive horsepower into a high-performance body and to burn a lot of gasoline. We provide thrills in a different, subtler, more environmentally reasonable way. By closely coupling bodily motion with vehicular motion, and by making driving a more sensuous experience, we squeeze the maximum amount of thrill out of the minimum amount of energy. Our cars are lightweight, and – like surfboards and rollerblades – they don't actually have to go very fast to provide the sensation of graceful, joyous, exciting motion.

Modularizing manufacturing Our new automobile architecture – based upon the omnidirectional robot wheel – is highly modularized. This allows manufacturing processes to be subdivided among many enterprises, the mix-and-match combination of modular elements into new configurations, and the economical personalization of automobiles for small market niches or even individuals. The automobile industry becomes more like the personal computer industry, in which a highly modularized overall architecture allows many manufacturers to produce plug-compatible components that can be combined in endless variations. You can configure your machine, online, the way you want it. The variations shown here illustrate this principle.

Doing it with software

In a traditional automobile, the performance characteristics are largely determined by mechanical devices, and they are difficult to change. In our cars, by contrast, many of the key elements – particularly the wheels – are intelligent and programmable. This means that you can instantly customize your car by loading software, just as you customize the functions of your personal computer or music player. Think of your car as a device that you load with moves, just as you load your iPod with music.

Transology: *Movement in the city*

The carriageless horse

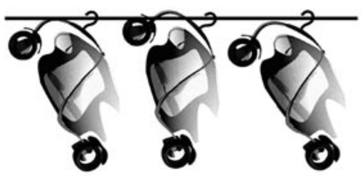
When the pioneers of the automobile removed the horse to create the horseless carriage, they removed the intelligence as well. Now, through electronics and software, we can put the intelligence back in. This takes us back to something that was, sadly, lost – to the complex, graceful, articulated motion of the horse rather than the rigid, clunky motion of the carriage. The carriageless horse becomes our new model.

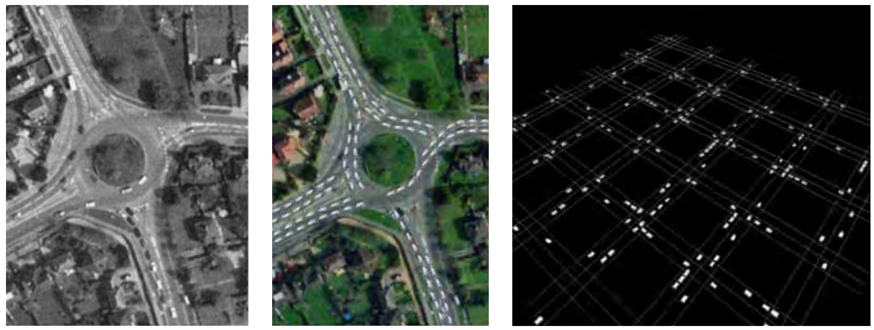
Dancing in the street

We are tired of cities that force people to move around in rigid, clanking, cumbersome, often dangerous metal capsules – cars, trains, elevators, escalators, and all the rest. We propose cities that are softer, gentler, and more sensual. We propose cities in which crude power, noise, and pollution give way to graceful finesse.

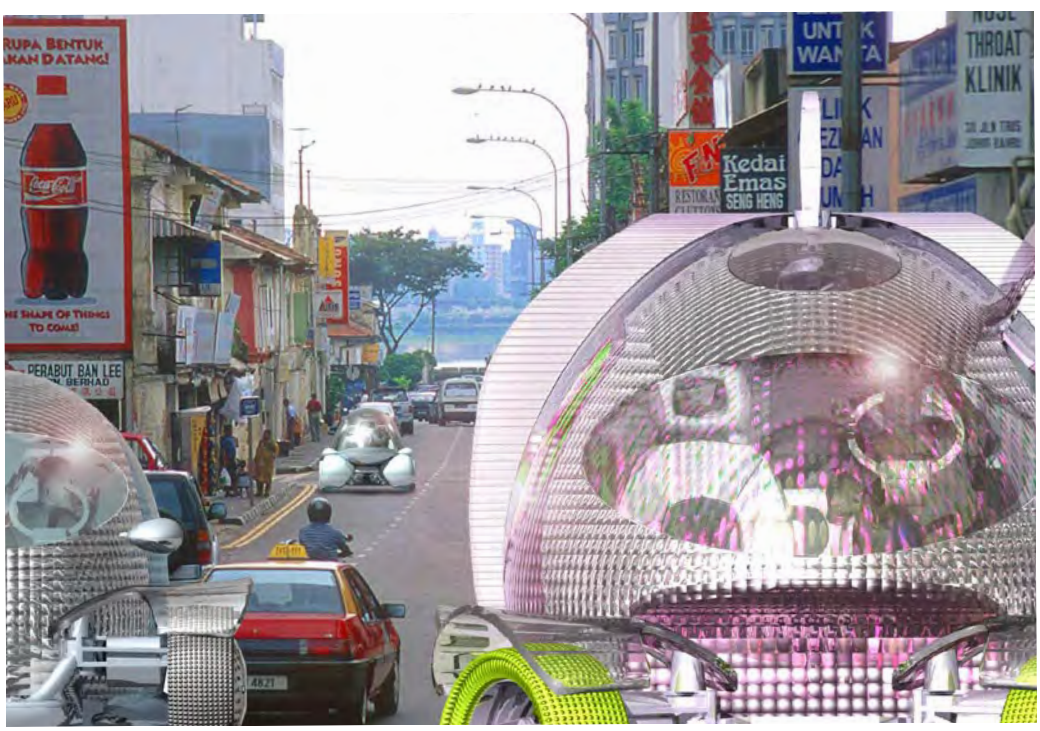
Gentle congestion

Traffic: *Mobility Wisdom*

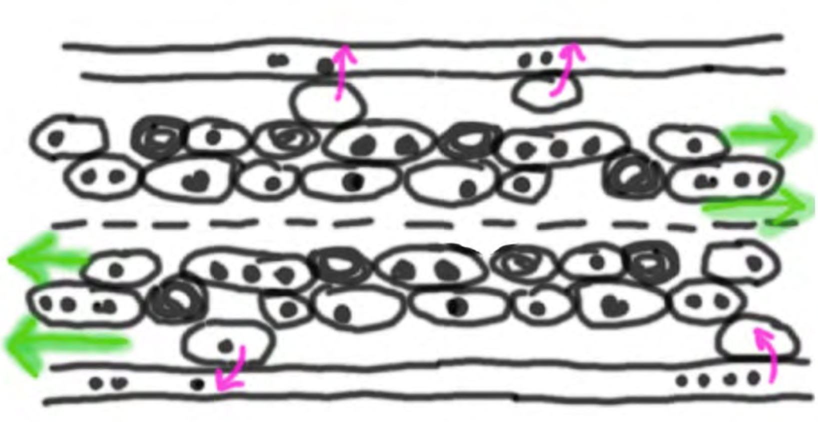




These soft vehicles (with on-board intel) are intended to share the streetscape and support interaction with the local denizens. It is a slow-motion vehicle anticipating the presence of surrounding bodies, not just its operator. Imagine a city street as a place of pleasured motion, elective and free for all occupants. Softer transports support a social theory of gentle congestion, with "on-the-fly" transfers, and veritable encounters between users and neighbors. Traffic in the realm of soft cars thus becomes a desire, not a concern. In this case the streets evolve into a flowing culture of constant mobility and informal meeting spaces.



Our concept continually redefines the drivers relationship to the car and to the city. This metropolitan car prototype is vitally based on the reduction of body weight. We used many solutions based on expandable pneumatic muscles and lightweight foil enclosures. The materials normally composing the outer body of the typical car are 44% of the entire mass of the vehicle. Reducing the mass thus increases fuel efficiency and acutely lowers the ecological footprint. One concept utilizing a pneumatic air bladder envelope dramati-



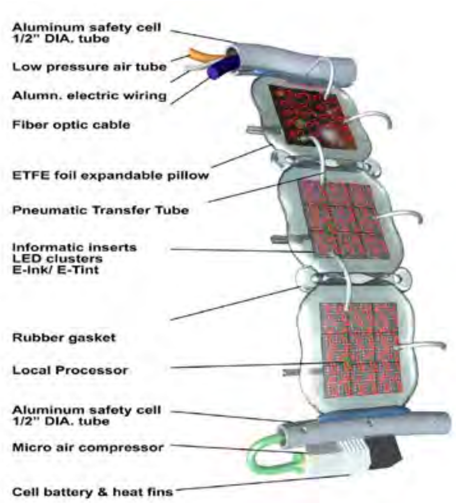
cally achieves this weight reduction. This vehicle design replaces most upper chassis and body components with pressurized struts, starch foam, ETFE foil (ethyltetrafluoroethylene), and sparse recyclable metal mesh reinforcing. The intention is to homogenize soft material usage, increase manufacturability, and design for disassembly. By making car bodies softer and lighter an effective green design signal is unleashed. In the life cycle of a car the ease of material transportation will benefit its every purpose from cradle to cradle; in production, maintenance, and reuse. Significantly these urban soft cars are further meant to act as a social guide to the city. We think of this bond between driver and car as a kind of neoteric Roy Rogers and Trigger (his trusty astute horse).

mnidirectional

Movement: *Driving sideways - from driving to parking to vertical ascent*

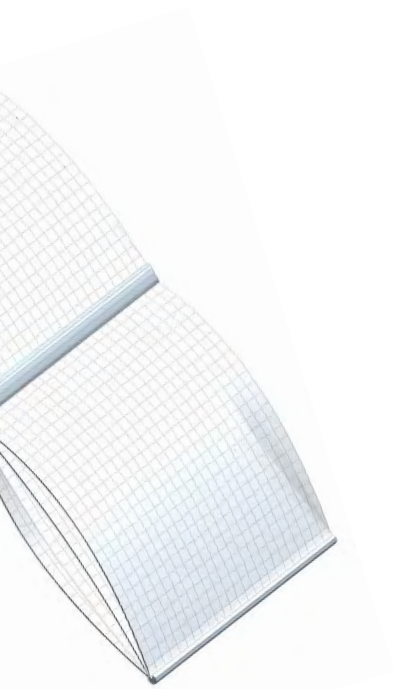
Unquestionably, automobile design has become too firmly established and conventional. As a result our challenge was to re-think the fundamental core architecture of mobility. We investigated thousands of notions and tangential perceptions using sophisticated computational means including parametrics, geometric modeling, and CAD/CAM. Good design needed to respect all lines of desire no matter how arcane or hi-tech to achieve its objectives. The thought of limiting ourselves to a single base-line implementation or method was ludicrous. Instead our vision of urban mobility developed out of a deeply collaborative process across multiple disciplines.

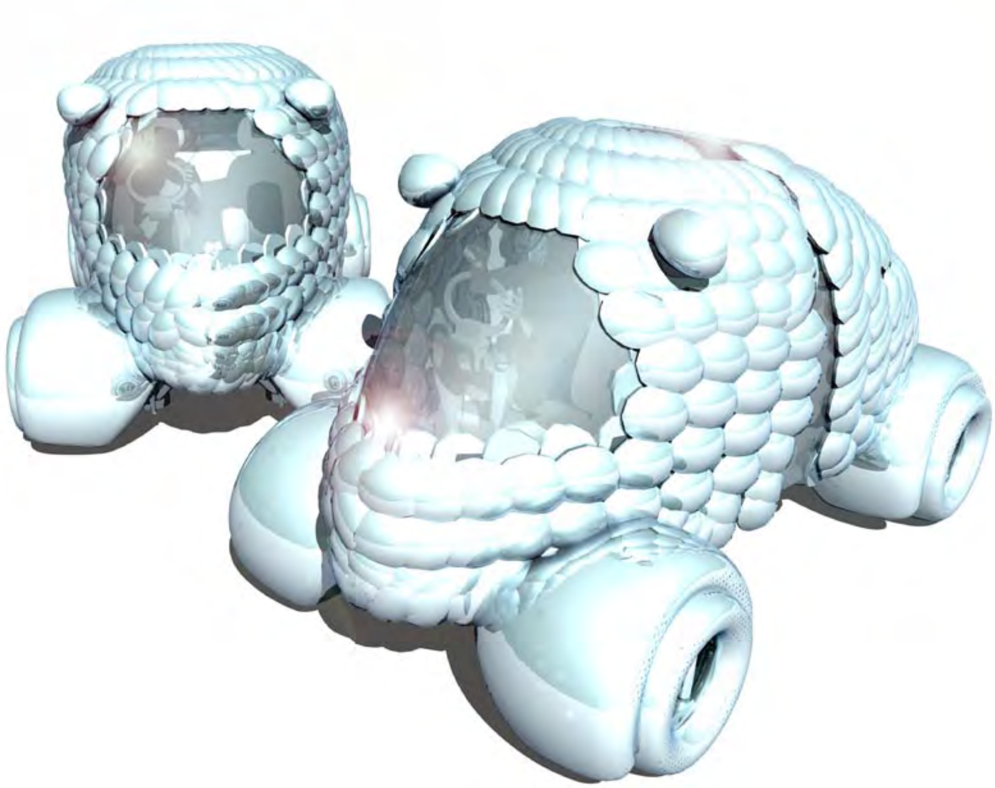
Softness



Cushion: *Transparent skin with integrated displays*

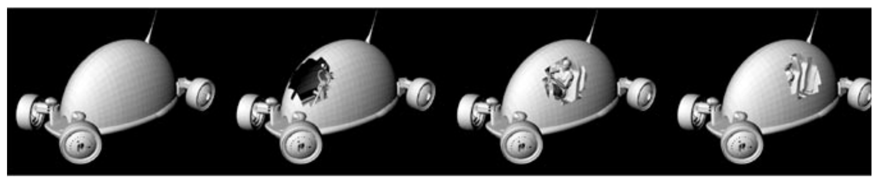
Other critical aspects of our designs integrate the following innovations: athletic actuation, reconfigurable air bladder seating (including a six point safety air bag), AUTOnomy "skateboard" chassis, organic LED clusters, E-tinting, social projections, hubless wheels, and drive-by-wire systems. All of these features are comprised to reveal the intense re-adapting of the city vehicle. One ultimate goal is to proffer a car that is predicated on ecological accountability. If the invention of the automobile and its ensuing use has depleted the health of the planet, then mitigating solutions are a colossal obligation. A single such example is a car that scrubs the air of pollutions it previously caused.



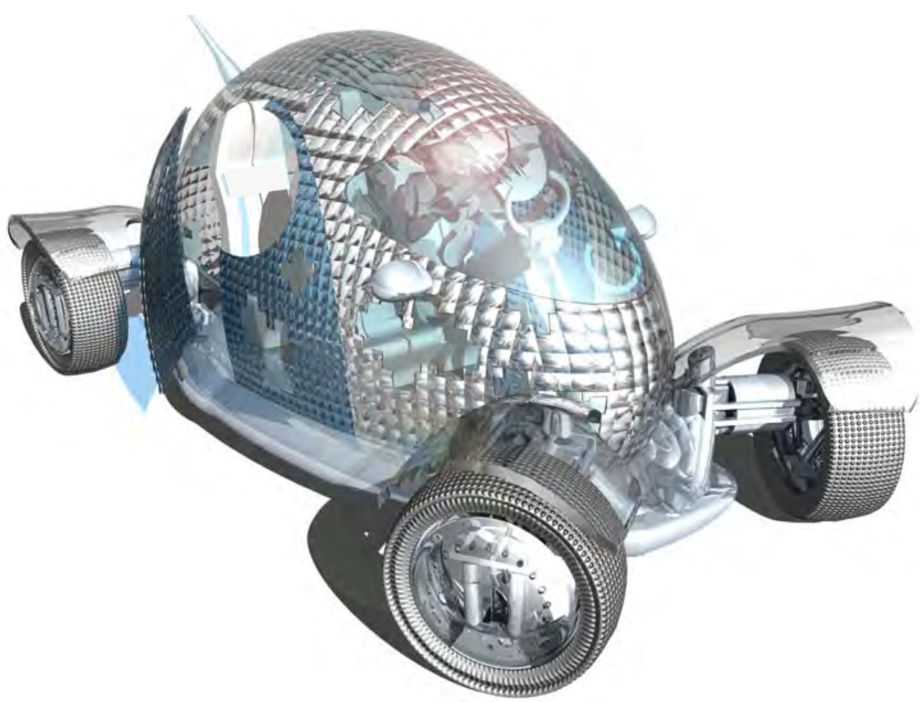


Adaptation

Material: *Transparency travels with the view of the driver*

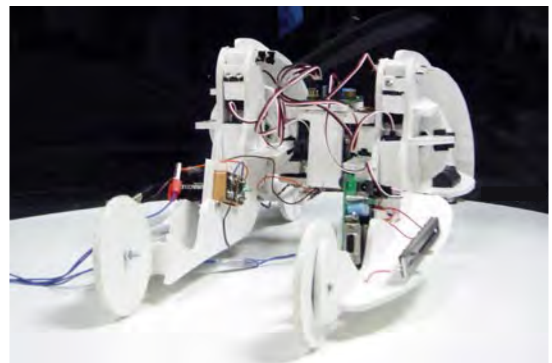


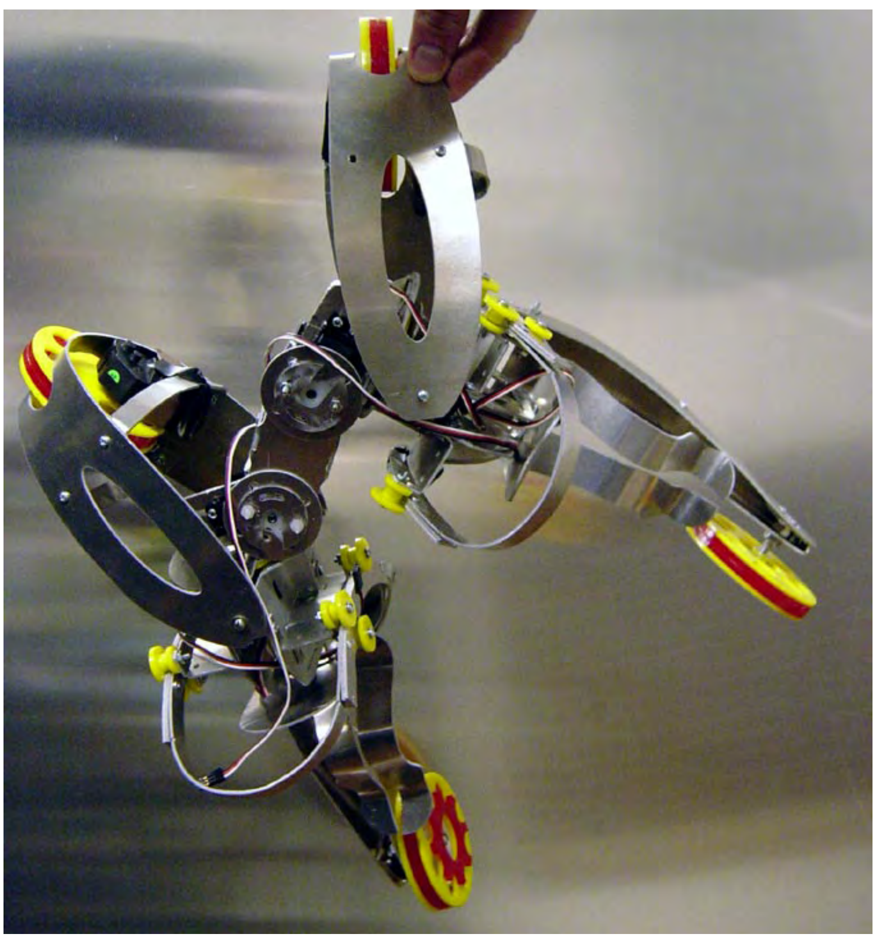
More efficient cars are less harmful alternatives but still contribute to the problem. In its place we propose repairing the damage already done via on-board hydrogen reformation, etc. An ecologically salient transport can fit into its urban context and value the need for all life to breathe.
As a substitute of only offering a single solution, we have articulated a field of critical exemplary conditions. Eventually we shaped each of these multiple design paths into distinct compositions. Therefore at every stage a new iconic representation was produced that essentially portrayed that chapter of design. As of now the research work is still on-going.

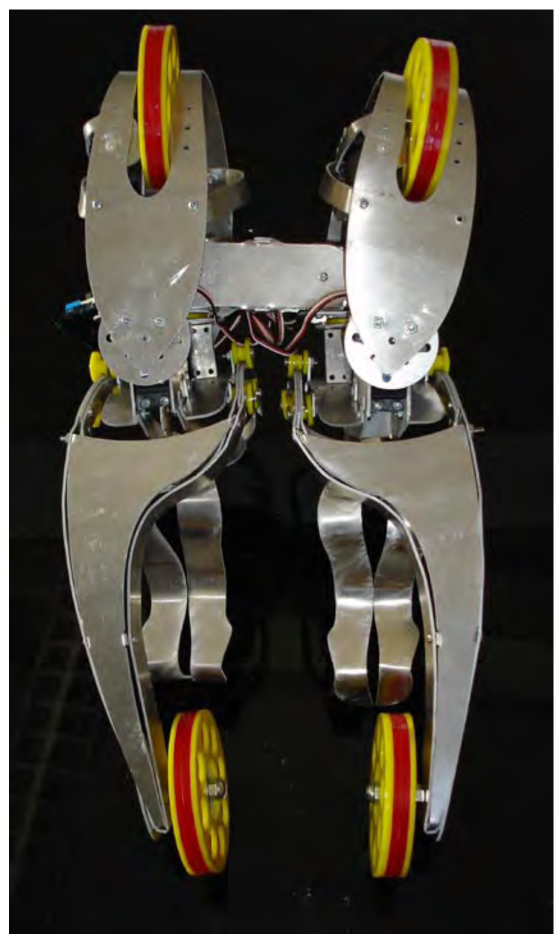


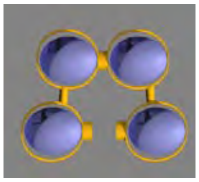
A water jet cut sheet aluminum model was designed, in which eight servos control the eight degrees of freedom of the model. The degrees of freedom are the following: Two degrees for the ski like movement of the two drivers against each other, two degrees for the banking of the passengers, two degrees for the steering of the back wheels in respect to the front wheels and two degrees for arching each pods midsection to accommodate for no planarity of the four wheels in sharp turns.

Actuation: *Robotic frame study*







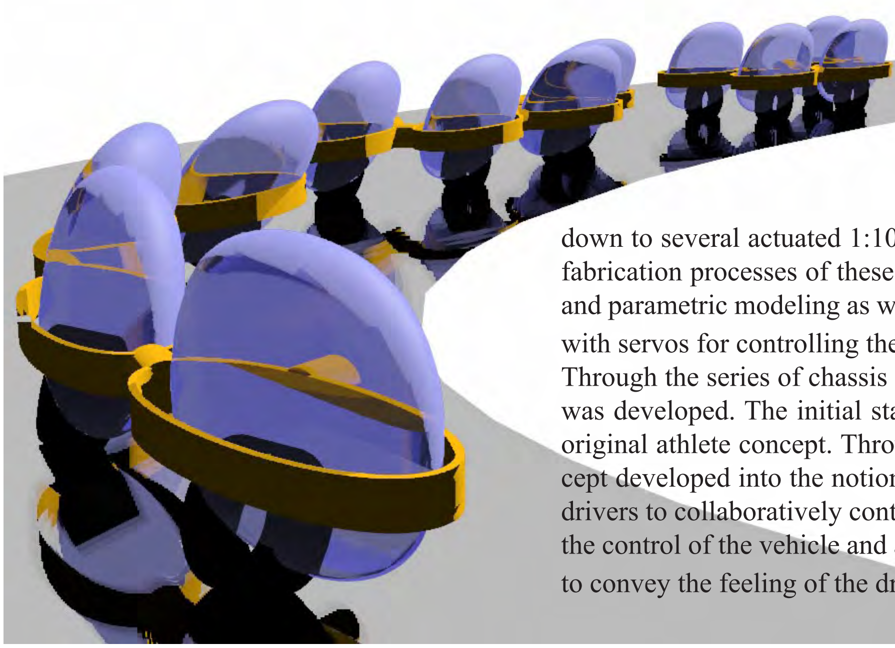


rticulation

The Athlete: *Articulated Vehicle Chassis - no more bricks on wheels*

This project traces the development of a novel car architecture and its intelligent articulated chassis through a series of design explorations using parametric and model building iterations. The relationship between driver and passenger was the driver for the basic vehicle configuration. The designs discussed here explores the possibility of a smart, adaptable chassis architecture that allows for steering and banking through a series of articulated and actuated joints that replace the static chassis of today's cars.

The goal is to redefine performance driving by creating a vehicle that is versatile and agile, that exhilarates by articulation in response to the driver's movements, rather than by having excessive amounts of horsepower. We put the design process into the context of generative approaches in architecture and point out relevant links to cognitive robotics. The articulated nature of the car poses a challenge in how to control its eight degrees of freedom with respect to the plane it is moving on. The H-type project is illustrated in detail



down to several actuated 1:10 mockups used for testing of the platform. The fabrication processes of these platforms involved the use of water jet cutting and parametric modeling as well as the use of micro controllers in connection with servos for controlling the actuation.

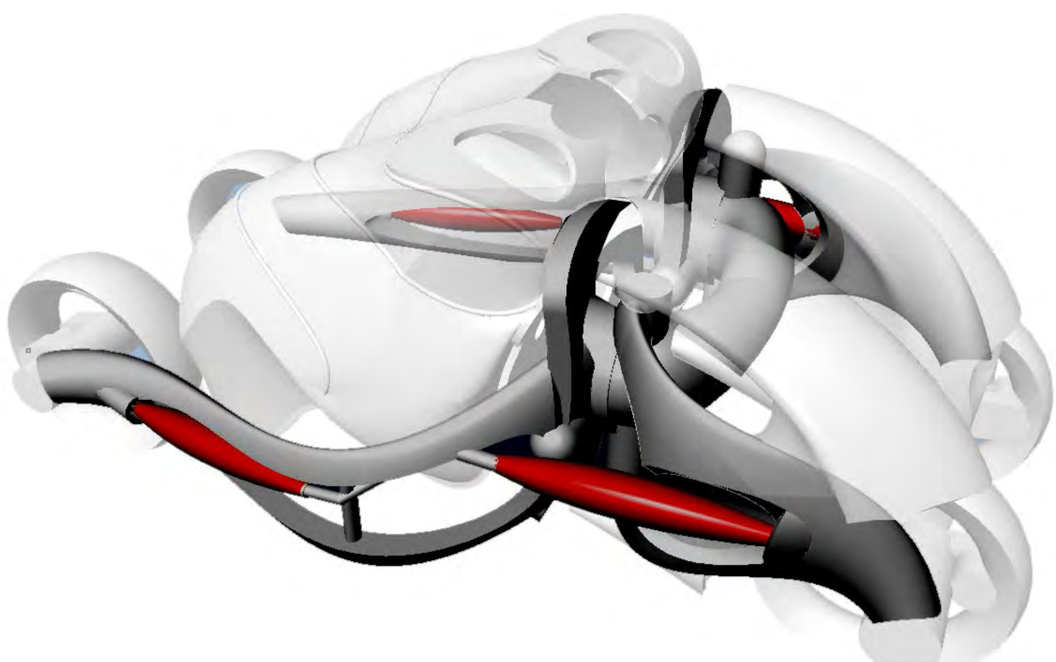
Through the series of chassis developments a new chassis type, "the H-type" was developed. The initial starting point was the BMW skateboard inspired original athlete concept. Through a series of brainstorming sessions the concept developed into the notion of a fully articulated platform that allows two drivers to collaboratively control the vehicle. The seating acts as the input for the control of the vehicle and also responds by banking into the turns in order to convey the feeling of the driving forces.

The articulation of the chassis brings a unique challenge to the envelope of the vehicle. The enclosure is supposed to protect from the elements but at the same time not obstruct the articulation of the skeleton. It has to provide some rigidity to hold up under the forces of driving and provide transparency to work as a windshield. Previous studies looked into the possibility of using inflatable wall structures similar to the image below. The biggest challenge with pneumatic skins is to achieve the appropriate rigidity and maintain transparency at the same time.

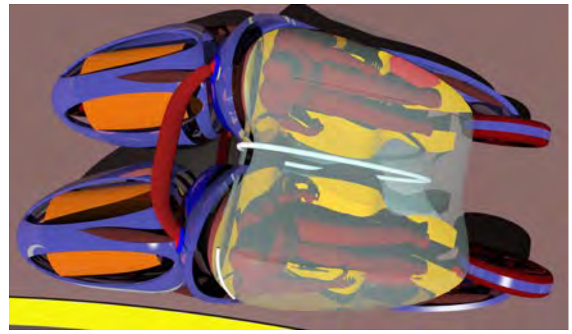
The study of human movement as control input for steering the car. A core aspect of the articulated car is the mapping of the movement of the drivers onto the skeleton of the car to allow for dance like collaborative driving. The movement of legs and arms are to be used as driving input based on a special seat that senses the movement and translates it into control output for the eight

Mapping: *Building a car around the movement of the drivers*

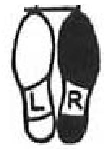
joints of the vehicle. Several movement studies were created to study the range of motion for controlling the car. This shows excerpts from one of the animation sequence that shows how the vehicle is constructed around the movement of the drivers.

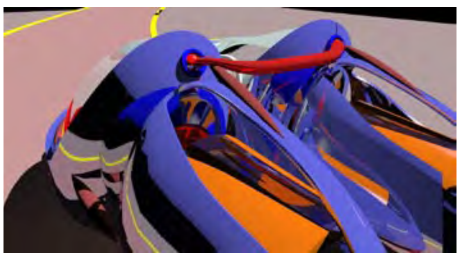


-Type

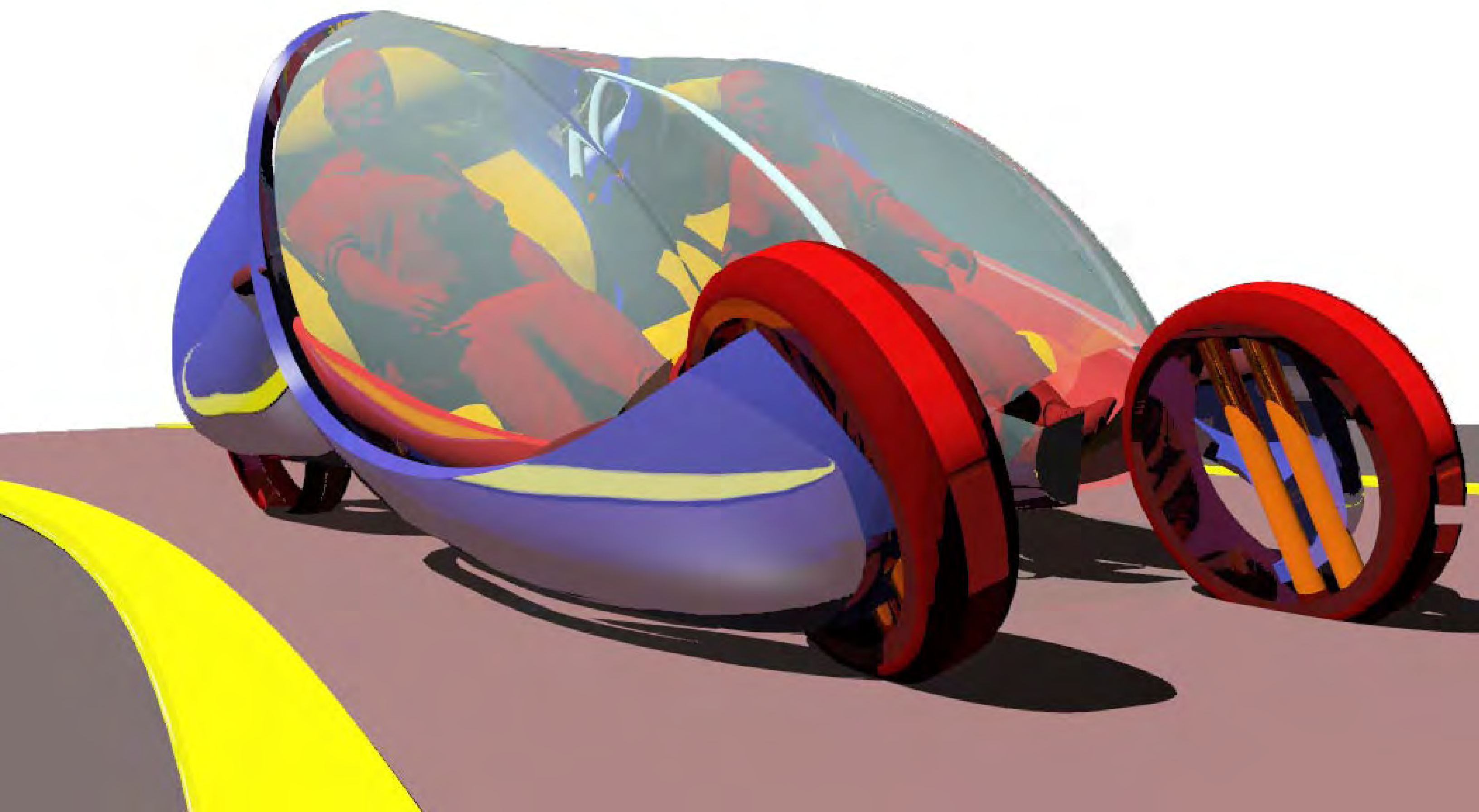


H-Type: *From thinking about minimal footprint to laying out*

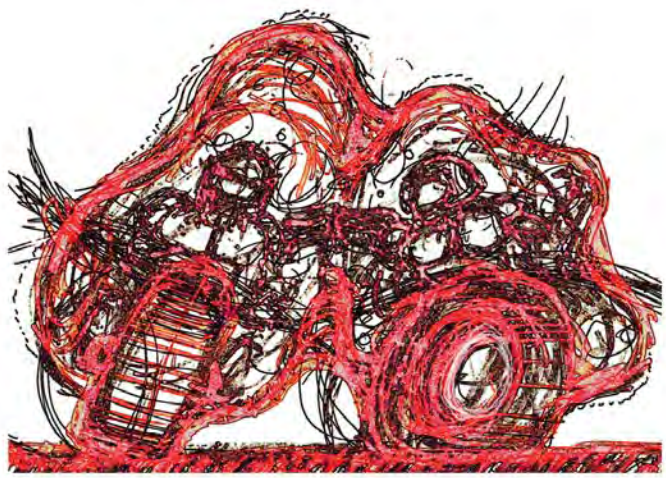




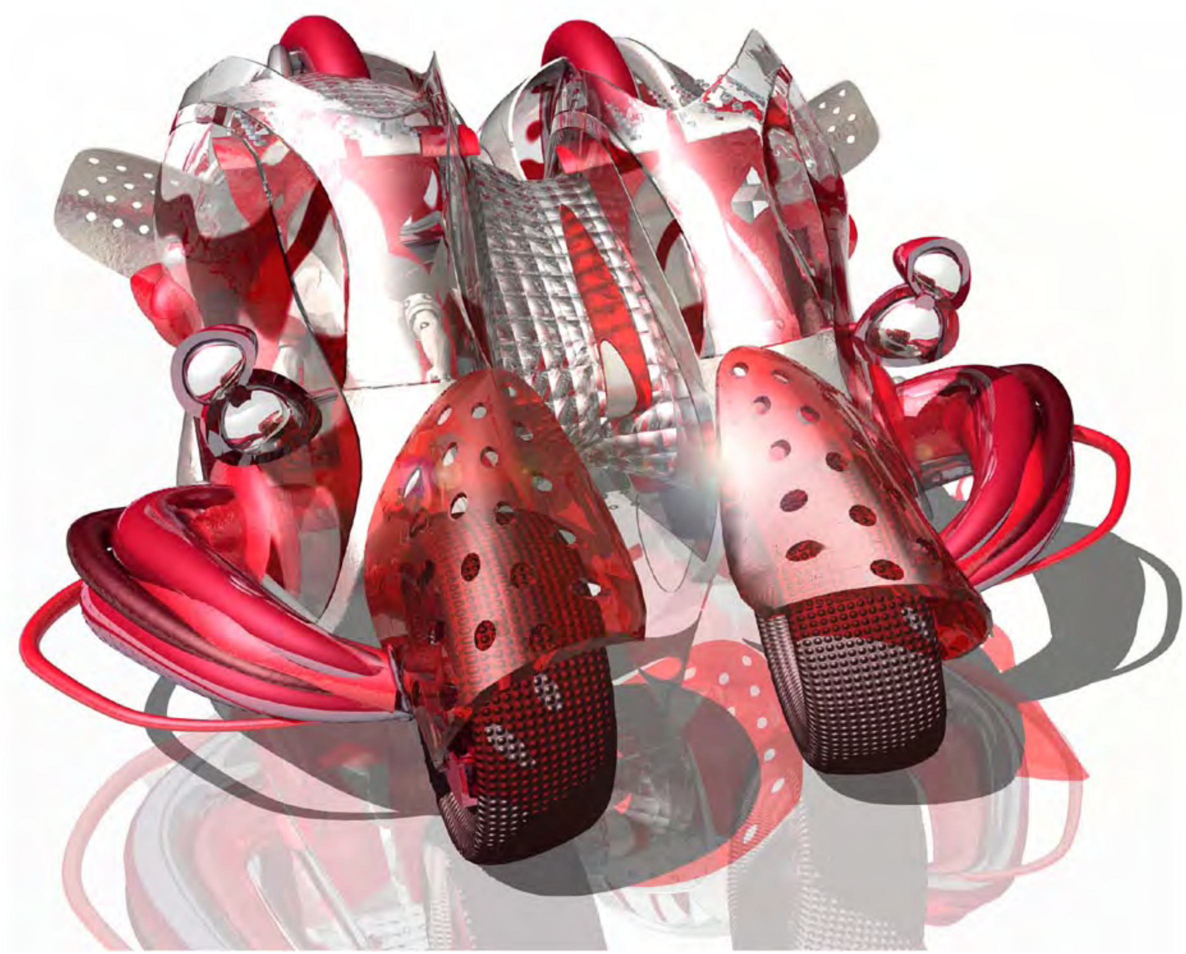
Based on the "H-Type" a number of visualization studies were made to study the expression of this novel vehicle architecture. The challenge was to find an adequate expression for a novel vehicle concept but still seems familiar enough to be credible as a full-scale concept car in the future. The designs varied from more extreme versions to the ones that were tested in physical prototypes. The one shown here explores the celebration of the wheels in front of the drivers and an exposed powertrain in the rear pods propelling the car forward. The many degrees of freedom in the frame pose a unique challenge to programming the movements.



Under this arrangement, there is no need to be limited to just one driver. Some of our cars are controlled by the coordinated motions of two drivers – much as with a motorcycle and sidecar, or a two-person sailboat. The idea can be extended to any number of riders. The distinction between driver and passengers disappears; driving can become – when we wish – a partnership or even a team sport.

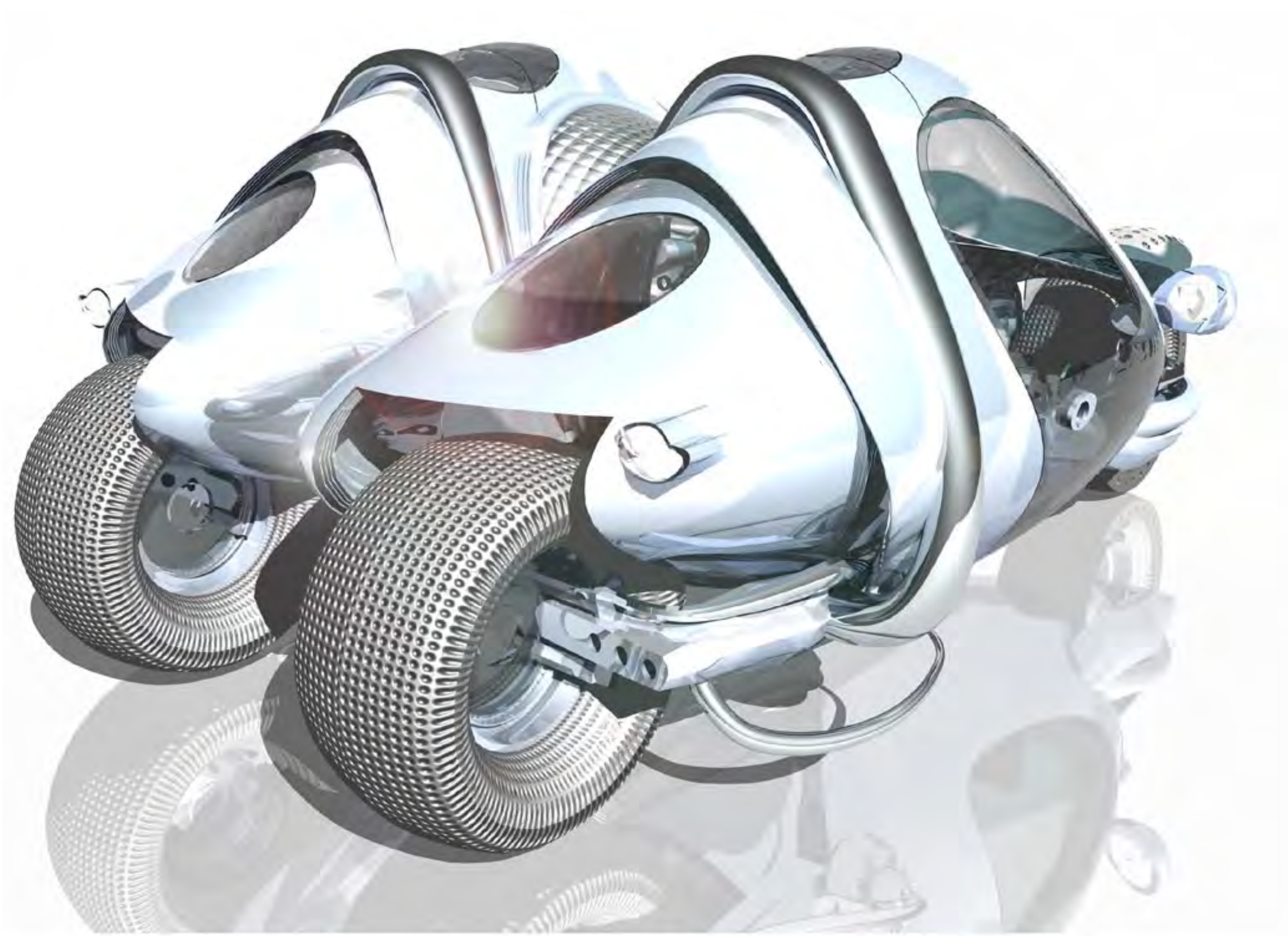


Linked: *Making it a team*



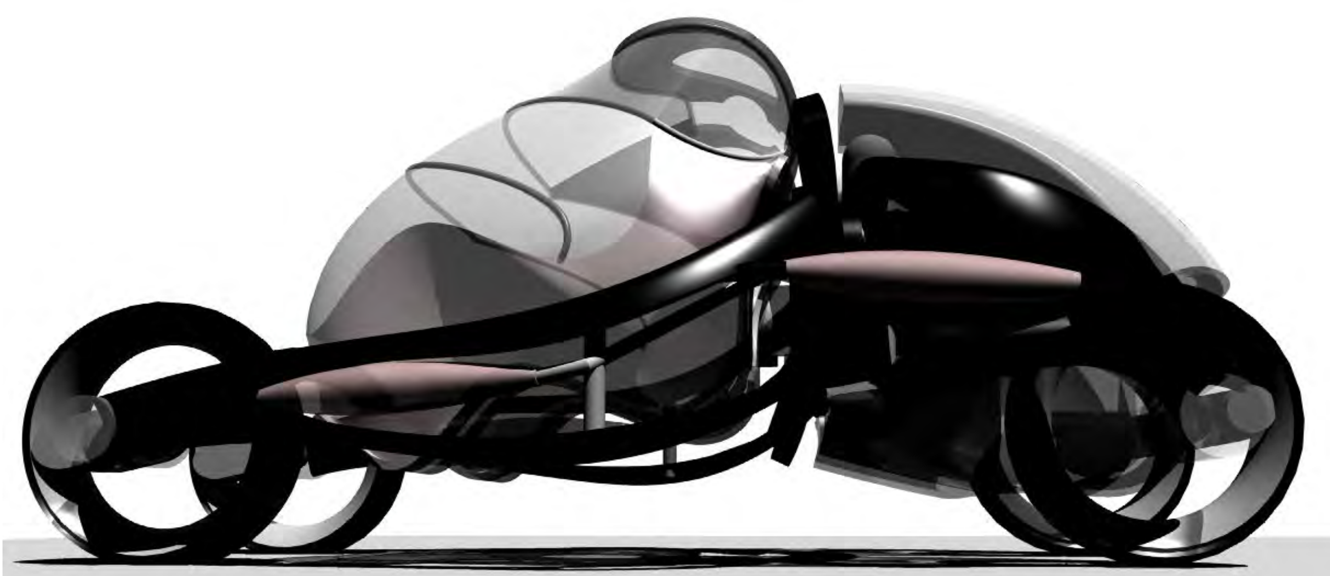
The usual way to make a fun automobile is to put excessive horsepower into a high-performance body and to burn a lot of gasoline. We provide thrills in a different, subtler, more environmentally reasonable way. By closely coupling bodily motion with vehicular motion, and by making driving a more sensuous experience, we squeeze the maximum amount of thrill out of the minimum amount of energy. Our cars are lightweight, and – like surfboards and roller-blades – they don't actually have to go very fast to provide the sensation of graceful, joyous, exciting motion.

Jackets: *Getting the most out of the least*



Sneaker Car: *Wearing your ride*

The car becomes a piece of sporting equipment or a piece of clothing. It is assembled more like an oversized sneaker out of soft and semi-rigid components and moves and stretches with the drivers movements.The skeleton with pneumatic Festo muscles is reflecting the agility of the cars movements. The windshield is the only rigid part in the envelope assembly and also acts as ingress and egress for the drivers. The H configuration of the frame shows clearly the hip as the central control element negotiating between the two drivers.



h-Series: *Riding the wheel - Condensing the athlete concept*

The next step is the development of 1:1 models to test the form and functionality and concept. The prototypes will test driving and steering dynamics as well as the stability of the overall platform.

A central element is the development of the seat that senses the drivers movement and translates them into steering movements in the wheel. It is based on the principle of the exoskeleton, which means all rotation points are projected inside the drivers body and the structure supports the human skeleton from the outside.

The closest related examples are found in sports like skiing, which is very much reliant on the feedback loop between skier and skis to keep direction and balance. The mini athlete differs in terms of scale and in a reduced complexity that makes its control in normal driving circumstance not much more demanding then the control of a conventional car.