RUF climate solutions

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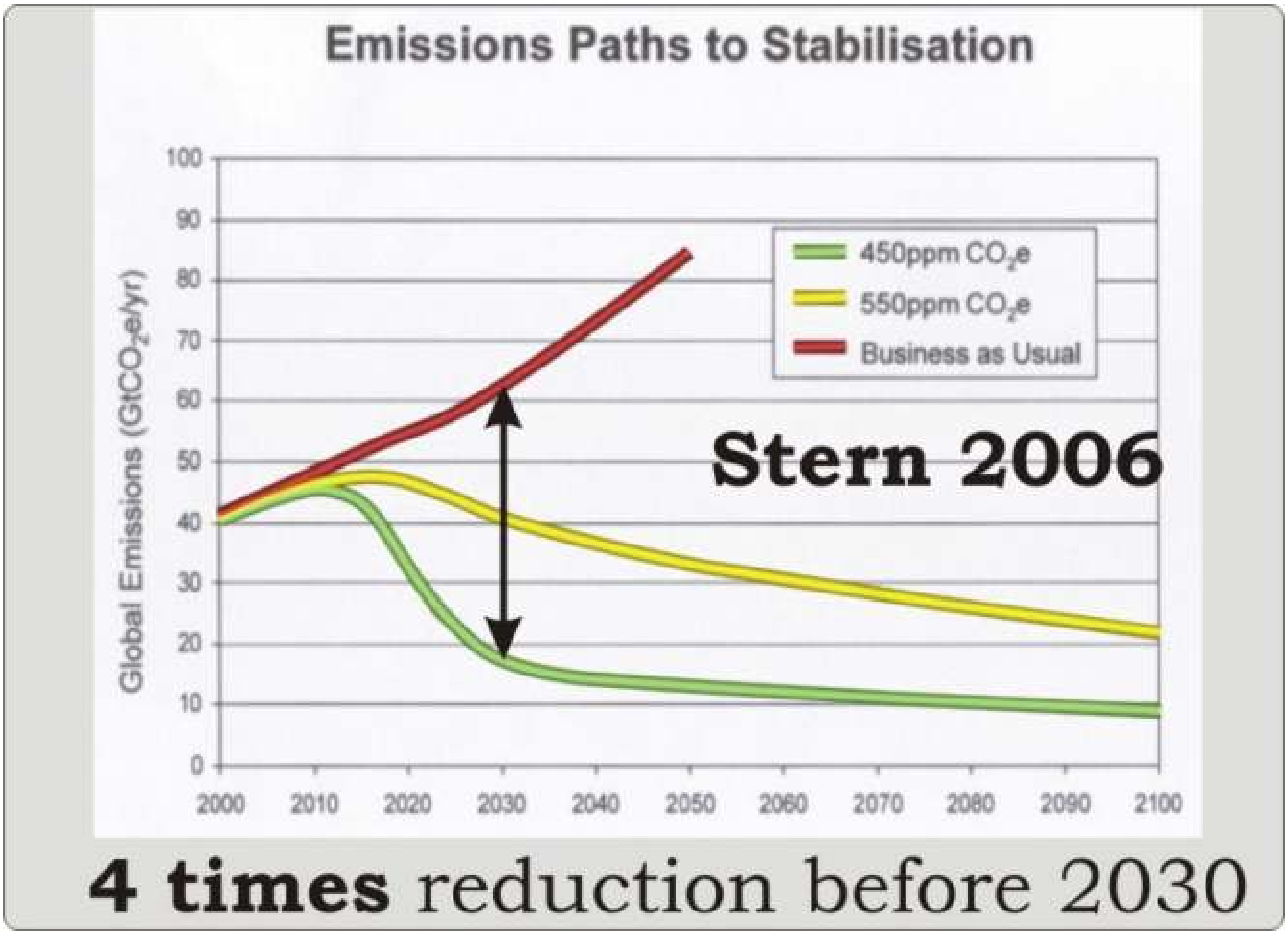
Resumé

Recent studies (Stern 2006) have shown that in order to avoid catastrophic climate effects, the equivalent CO_2 emission levels must be reduced by a factor 4 in the 21st century.



This is a very demanding task, especially in the transportation sector.
The growing population in China and India will insist on the same level of mobility as we in the west take for granted. This is not possible unless the transportation sector reduces its CO_2 emissions to far below 20% of its present level.
Current car technology can be improved approx. 30% over the next 20 years but at the same time traffic volumes will increase more than 30% in the western societies and even more in China and India.
It is very important to realize that new technologies must be developed in order to solve the problems.

The good news is that it is possible using a new transport technology called dualmode to meet the demands and at the same time offer massive user advantages.
RUF (Rapid Urban Flexible) is such a system. See: www.ruf.dk

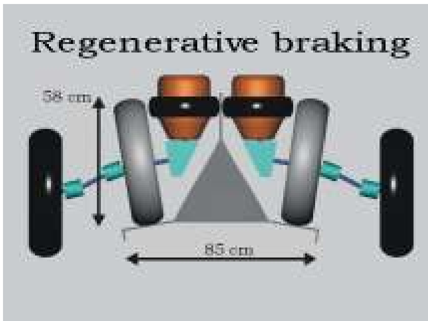
What is RUF ?

RUF (Rapid Urban Flexible) is a new transport system based upon the dualmode principle.

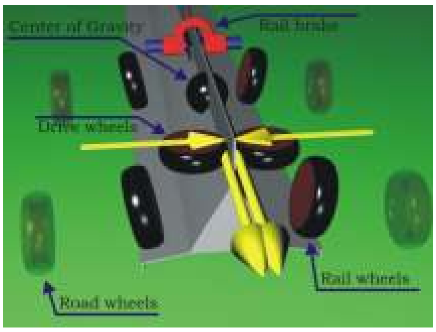
RUF uses a network of electrified guideways to supplement the highway system.

Ruf (individual electric car)
A typical user will drive a few kilometers on the small roads driven by small batteries. The long distances at high speed (150 km/h) will be driven on the monorail, closely coupled with other rufs, in a small train. The air resistance will be much reduced.

The vehicles need no friction to steer and brake while on the monorail. The electric motors work as motor brakes and a special rail brake is used as an emergency brake.
This will reduce the rolling resistance and braking energy will be regained.



RUF can solve congestion problems by adding more capacity to the traffic system while at the same time save enough energy to limit the climate problems.



Maxi-ruf (electric public transport)
A typical user will call the system and ask for transport. He will be given several options. He can be transported door-to-door with high comfort if he wants to pay for it. He can also pay less and be transported at a lower level of service. He might have to walk to a pick-up place and he might have to transfer during the trip.
The expensive option is faster than by car today and he doesn't have to worry about parking at the destination. He can also use the travel time constructively, since he rides in the same seat for the entire trip.
Maxi-ruf is a light-weight bus/train and it runs on demand, so the number of passengers is high. RUF public transport is very energy efficient, quiet and non-polluting.

How can RUF help ?

RUF cars

RUF can reduce the air resistance by 4/5 at high speed.

Air resistance for a car driving alone at 100 km/h = 100
Air resistance for a ruf in a train of 10 rufs on the monorail = 20

RUF can reduce the rolling resistance by ½.

Rolling resistance for a car = 100
Rolling resistance for ruf on the monorail = 50

RUF can use electricity directly so losses are small.

Well to wheel energy losses for a car = 100
Well to wheel energy losses for RUF = 75

RUF can use regenerative braking to save energy.

Brake energy losses for a car = 100
Brake energy losses for a ruf = 50

RUF does not run idle.

Energy losses from a car running idle = 100
Energy losses from a ruf standing still with lights on = 10

RUF as public transport

RUF as public transport has the same qualities as the RUF cars and since the number of passengers per vehicle is much higher, the advantages for the climate are even greater.

RESULT:

RUF can run 4 times longer per energy unit than a gasoline car.

RUF can run on renewable sources that do not emit CO_2

What is wrong with the car ?

Cars are beautiful, convenient and fast.
The cars are so attractive that they are being strangled by their own success. What can be done to keep the best features of the car and at the same time reduce their problems.

If you take a step back and look upon the car as a machine for moving people, you will discover some fundamental characteristics of the car as we know it:

Cars need to be separated from each other all the time. This means that every car has a vortex of turbulent air behind it consuming a lot of energy at high speed. It also means that that a car takes up far more space than its own dimensions.

Cars need friction between the tires and the road all the time. If they don’t have it, they will not be able to steer and brake.

Car engines are very inefficient. Normally only approximately 15% of the energy from the gasoline is available for propulsion at the wheels.

Car engines idle when the car is stopped at a traffic light or in congestion. It uses energy without moving.

The car chassis has to be heavy and strong in order to be able to withstand high speed collisions.

The car cannot safely drive itself. The driver has to be alert all the time even if the trip most times is exactly the same: from home to work and back.

What is the car of the future?

The car of the future has to be able to provide an answer to the following dilemmas:

Roadspace is limited in existing cities yet the demand for cars is increasing

Oil supply is limited yet the demand is ever increasing

The climate effects are increasing yet the cars keep emmitting more CO_2

The hydrogen car ?
A hydrogen car will be stuck in congestion like any other car. It may not depend on oil, but it uses energy very inefficiently. See: www.ruf.dk/hydrogen.doc

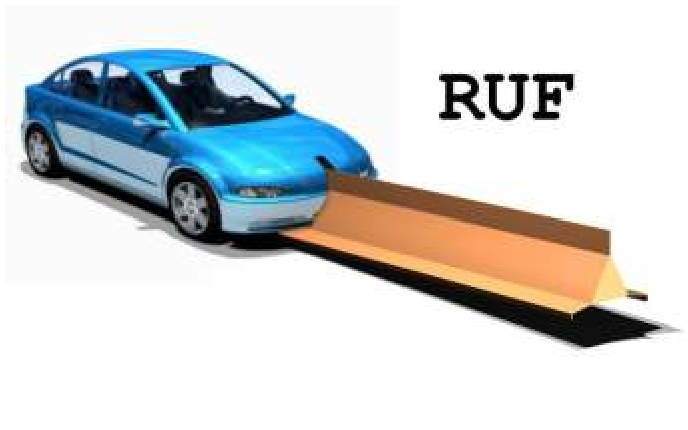
The ethanol car ?
A car running on ethanol will be stuck in congestion like any other car.
It takes a lot of valuable land area to grow enough biomass to produce the ethanol. It would be far better to burn the biomass in power plants as a substitute for coal.

The electric car (EV) ?
An electric car will be stuck in congestion like any other car.
The EV requires heavy batteries and a long charging period in order to function conveniently. It is more efficient than normal cars and very silent and non polluting in the near environment. The battery capacity can be used to store electricity from windmills and solar cells.

The Automated Highway System ?
Platooning of cars will increase the capacity of a highway, but is is very difficult to make it safe enough in all weather conditions. Implementation on an existing highway requires a very difficult transition period. Almost no energy savings are obtained.

Personal Rapid Transit (PRT) ?
PRT is a concept with individual “cars” using a special guideway to move the car automatically at a speed of typically 40 km/h. PRT is very energy efficient, but it cannot be used as a substitute for the car without building guideways everywhere.

RUF dualmode transport system !
RUF vehicles (busses and cars) do not suffer from highway congestion. RUF is very energy efficient and requires no oil as it runs on electricity.
RUF automation allows the driver to use commute time constructively.



What is wrong with P. T. ?

Public Transport is necessary in all societies because people who don't own a car or who are not able to drive one, need to be able to get around.

In order to provide affordable Public Transport, many people are squeezed into large units like busses and trains.

The difference in comfort level between the car and Public Transport is simply too large to attract passengers other than those who are forced to use it.

The farebox cannot normally cover the operating costs so the authorities try to limit the costs. This will reduce its attractiveness further and so fewer will use it.
It is a vicious downward spiral.

Capacity of a fully-loaded bus is large when it can operate at a reasonable speed and does not have to stop too often.

The reality today is, that busses are trapped in the traffic so the potentially high capacity cannot be used.

Standing passengers in Public Transport are in danger of being hurt when the bus or train suddenly needs to stop.

Even if there are seats enough, passengers need to leave their seat before the bus stops in order to be ready to leave the bus during the short stopping period. The chauffeur is under great pressure to keep up with the schedule so passengers often have a rough ride.

Passengers in Public Transport are sometimes exposed to the ill-health problems of other passengers.

Passengers in Public Transport feel insecure because they do not know the people with whom they share the limited space.

Bus vehicles in Public Transport are large and heavy. They make noise and some pollute with diesel particles. They also often destroy pavements because of their weight.

Large units are not mass produced like cars, so they are relatively expensive.

Public Transport vehicles are only energy efficient when they are full. In a typical schedule, they run nearly empty many hours of the day.

What is P.T. of the future ?

A maxi-ruf is a small electric bus, 2 m wide and 7 m long.

It is a dualmode bus. It can drive as a bus or as a train. The transition from road to rail is guided by magnetic fields and take place at 20 mph .

Access to the bus is extremely easy. There is a door for every seat.

Every passenger has a private seat with the same comfort as in a car.
No stranger is going to sit next to you.

It makes very little noise and produces no local pollution.

Maxi-ruf is a very energy-efficient way of moving people.

Travel time, from door-to-door, will often be shorter than using an auto.
See: www.ruf.dk/rufcph.exe

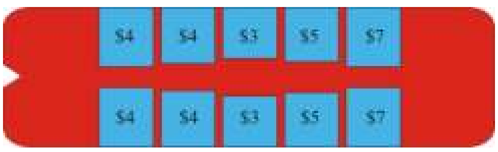
Best of all, there will be no parking problems at the destination.

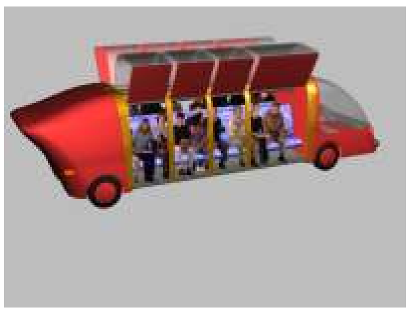
Up to 3 maxi-ruf can be coupled and driven along the streets with one chauffeur. On the monorail typically 5 maxi-rufs are coupled in a train (with or without a chauffeur).

Higher fares would allow you to order a highly attractive door-to-door trip or you can choose the lowest fare which means you will have to walk to a pick-up place and may have to transfer a couple of times during the trip.

Public transport with RUF can also be obtained by renting a public ruf. Ordering and payment would be via electronic personal devices.

A high capacity version of maxi-ruf is called mega-ruf. It can carry 20 passengers using a different seating arrangement.





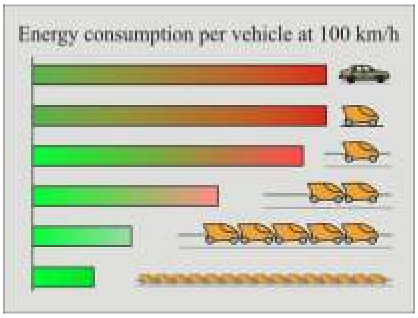
Air resistance

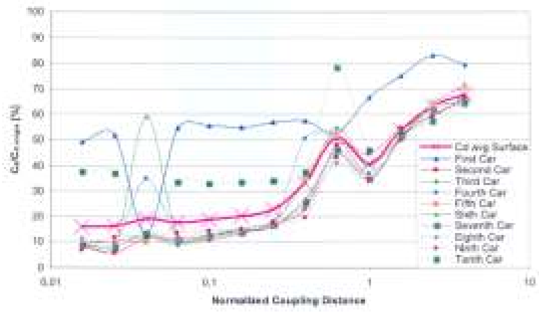
A car driving at 100 km/h along a highway will create a vortex of air behind the vehicle all the time. This vortex will consume a lot of the energy delivered to the wheels.

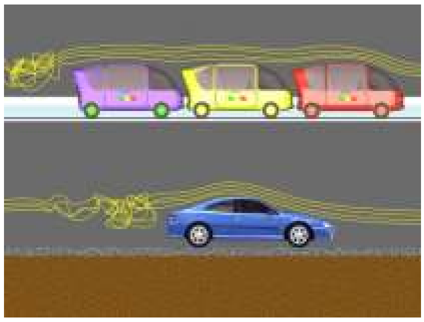
A RUF vehicle follows the RUF standard which requires that the vehicle must be able to be closely coupled to other vehicles to form a train. The RUF standard also requires that the shapes of the front and the rear fit reasonably well together.

According to an estimate from the Laboratory of Energy Technology at the Danish Technical University, a ruf in the middle of a train will only add 10% to the air resistance of the train. This estimate has in 2008 been confirmed using computer simulation tools and a wind tunnel test.

A reasonably long train (10 rufs) will reduce the air resistance to 1/5 of the amount per vehicle if they all drove alone at the same speed.



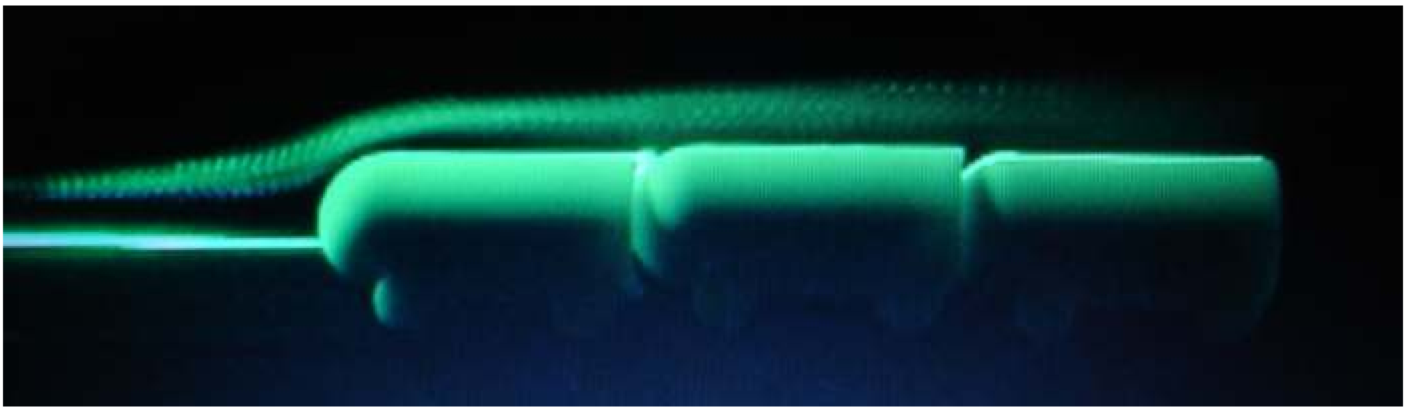




At high speed the air resistance is the dominant resistance, so this reduction effect is very important.

In a typical network, the distance between the junctions is 5 km. Most of this distance will be driven at high speed (150 km/h).

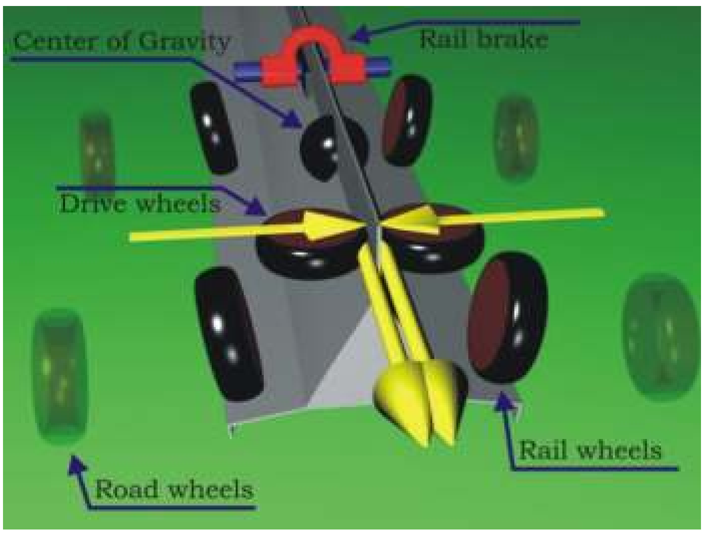
A ruf is slightly higher than a normal car due to the built-in channel in the middle. For this reason, the air resistance while driving on roads will be slightly higher than a car. Normally, conventional roads will only be used for a few km at limited speed to get to the monorail system, so this effect is very small.

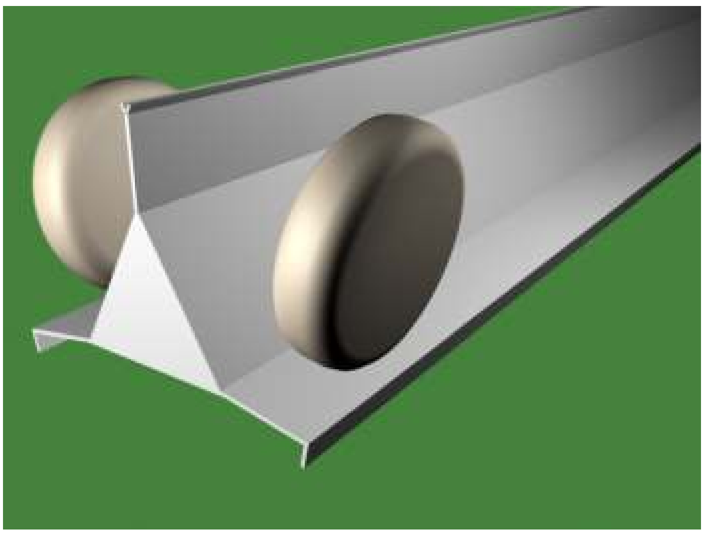


Rolling resistance

Cars use the roads all the time. Their steering and braking depend critically on the friction between road and wheels. If the road is slippery, an accident is often the result. The wheels need to be air filled in order to be able to handle potholes in the road.
The friction depends on the tire pressure. Low pressure can increase rolling resistance by as much as 20%. At high speed the vehicles can be lifted due to aerodynamic forces. If friction is decreased, a dangerous situation can arise.

RUF vehicles only drive a short distance along conventional roads at low speed. Most of the distance is driven via the monorail where steering is no problem and braking uses either the drive wheels or the rail brake (emergency braking).
This means that the wheels carrying the vehicles can be smooth wheels with fixed rubber, low rolling resistance and low noise.
Aerodynamic lift is no problem. It is actually an advantage if the weight of the vehicle is partly lifted on the monorail. The RUF vehicles are always safely “locked” to the monorail. Since collisions on the monorail are almost impossible, the chassis of the vehicles can be made from light-weight material. Low weight produces low rolling resistance.





Regenerative braking

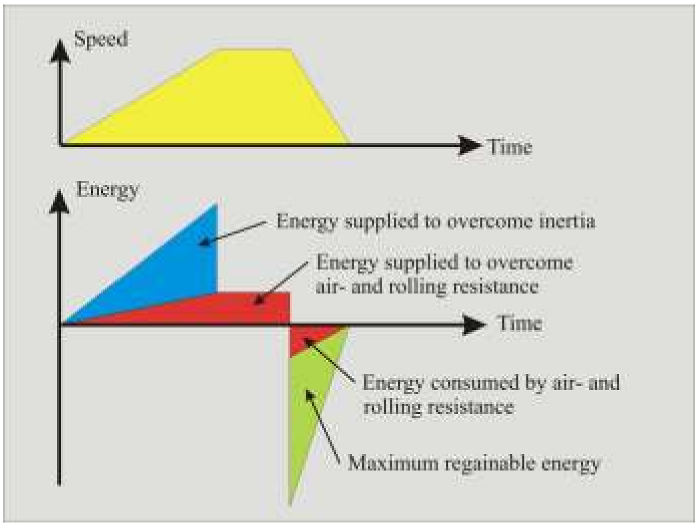
In city traffic, vehicles have to stop numerous times. Each time, the energy stored as motion of the vehicle mass, is wasted as heat in the brakes.
On a congested highway, cars have to slow down frequently from high speed, so they waste a lot of energy.
A normal car cannot regain any of this energy.
A normal electric car or a hybrid car can regain some of this energy by using the electric motors in reverse and sending power back into the battery.
This is not ideal since batteries cannot tolerate large charging currents. The critical life time of the batteries will be shortened and a battery replacement is expensive.

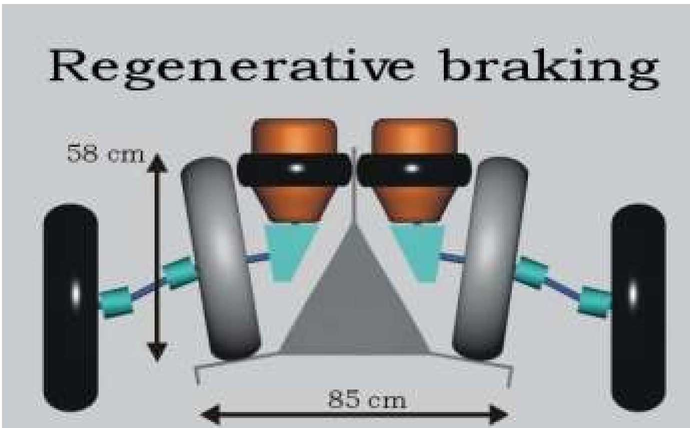
Since most of the typical trip in a RUF system takes place on the monorail, RUF can regain more braking energy than normal electric cars. In a normal commuter situation, the commuter will drive 2-3 km along minor streets to get to the monorail network. He or she will then use the network for 15 km (typically) and then again use the normal roads for the last 2-3 km to the destination.

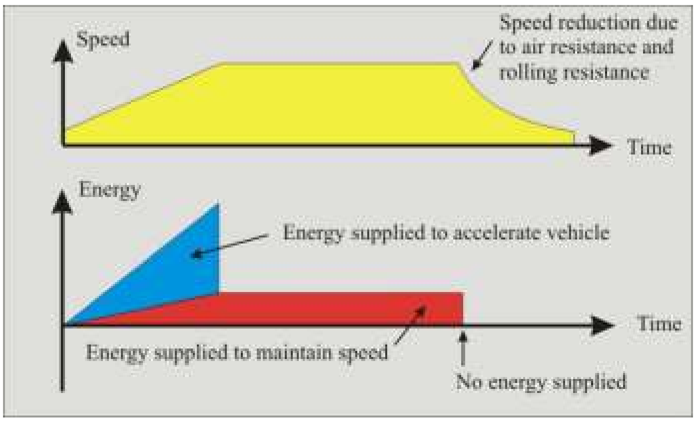
When RUF vehicles are using the monorail, the braking energy is not sent to the batteries but it is sent back into the power rails. This way, the batteries are not overloaded and almost all the braking energy can be sent back into the system.

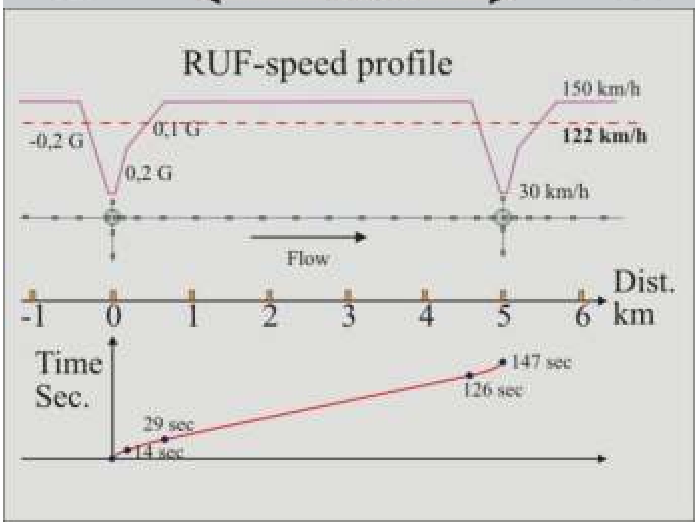
It is also possible to avoid braking completely on the monorail and use the air resistance and rolling resistance to gently slow down the train to 30 km/h at the next junction.

Since the automated part of the trip is system controlled, no unnecessary brakings will normally be required. In the case of an emergency braking, the rail brake will take over.







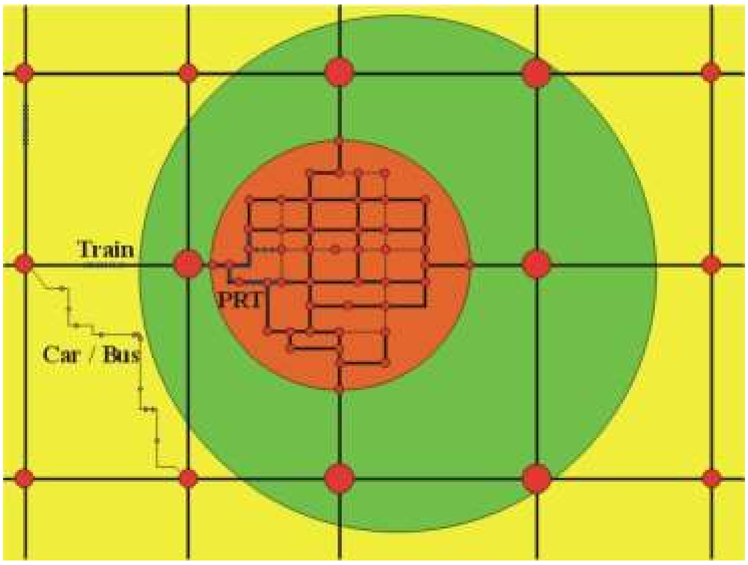


Other relevant aspects

A city using a RUF network as its main transport system, will be better prepared for critical situations where the energy consumption has to be cut sharply and quickly.

Expanded network

If the density of the network is increased, the advantages will increase since a larger portion of the trip will be taken on the monorail. The RUF network can be very dense in the dense parts of the town (just like a dense PRT system).



Speed reduction

If the RUF vehicle is equipped with IT devices, many commuters will be able to use the RUF system as a moving working place. A fast internet connection will make it possible to open e-mail, surf the internet and talk on the (video)phone while the vehicle moves slowly along the monorail network toward the office. Safety is high all the time.

It will take a longer time to get to the office, but since you are sitting in a "rolling office" it is not a big problem if part of your work is done via computer anyway.

The energy consumption can be reduced to almost nothing in this way.