meaning that there is virtually dry friction at the start. Swing bearings are an alternative system because they require very little energy to start moving. But, they are much more complicated to manufacture, they're expensive, cannot withstand radial loads, and are very loud.

fig. 15.18. Disc-diaphragm-wheel: construction (a), normal (b) and light-weight (c)

Usually the simpler and less expensive system, in this case the roller bearing, is selected as the basic system. How can we reduce the start energy so that it's like a swing bearing? Perhaps we could add micro-balls to the lubricant. We would then need considerably less initial energy and the usual rolling properties would be retained for normal work.

We can examine the idea of a string transportation system (STS) by A. Unitsky* as an example of the integration of different systems.

Ex. 112. String-transportation system by A. Unitsky. With which means of transportation are we starting into the new millennium? Will people slowly stagnate and be stuck in their psychological inhibitions – without alternative generations of automobiles and aircraft? Will the railroads continue to suck up resources to maintain its morally outdated technostructure? Will we finally understand that today our planet is no more secure than the "Titanic" was with its overestimated security where there were then way too few life boats?!

The car:

1. appeared at the end of the 19th century. Last century more than 10 million km of roads were built and about a billion cars were manufactured. Today a mid-class automobile costs $15-20,000.
2. A modern highway costs 5-10 million $/km, requires ca. 10 acres of land/km and ca. 20 acres/km of infrastructure. The scope of the soil and materials moved exceeds 50 thousand m³/km. Roads and their infrastructure have made ca. 120 million acres unusable for humanity. And this was certainly not the poorest ground! It corresponds roughly to the surface area of Germany and Great Britain. There are essentially no reserves left for the further construction of roads in Germany.
3. The yearly losses due to idle time spent in traffic jams are several billion dollars in Germany alone. Cars have become the number one cause of human death in the last few decades. According to figures from the WHO, more than 900,000

* This material was provided by Anatoly E. Unitsky

people die every year world-wide on roads from accidents and the injuries caused, many people live with grave injuries and disabilities, and more than 10 million people are injured.

4. The average speed on roads is 60-80 km/h; a car is parked for at least 90% of its lifecycle. The average length of stretches driven is 10-20 km. It is exhausting and dangerous to drive more that 400 km per day even on a highway in Germany.

5. Cars have become the main source of noise and air pollution in cities. Auto exhaust contains ca. 30 carcinogenic substances and more than 120 toxic bonds. The total energy use of cars exceeds the capacities of all power plants in the world!

6. Systems that supply traffic on roads such as oil wells and pipelines, oil processing and refineries, and asphalt manufacturers have an extremely negative effect on nature.

Railroad traffic:

1. the way we know it today, appeared at the beginning of the 19th century, even though the first stretches with recessed tracks already existed in ancient Rome. More than one million kilometers of railroad tracks have been laid world-wide.

2. Under the conditions that exist today, one kilometer of two-track railroad and its appropriate infrastructure costs $ 3 to 5 million. A passenger car cost ca. $ 1 million and an electric locomotive ca. $ 10 million. The construction requires many different resources: metal (steel, copper), steel reinforced concrete, gravel. The scope of the soil and materials moved is ca. 50 thousand m^3/km on the average. This takes ca. 10 acres per kilometer of ground use and up to 20 acres per kilometer of infrastructure.

3. Special constructions such as bridges, viaducts, overpasses and tunnels have to be built under complicated geographical conditions that make the system more expensive and increase the negative effect on the environment. The average speed on rails is 100-120 km/h.

4. Noise, vibrations, and thermal and electro-magnetic radiation caused by trains influence the life spaces of animals and people who live close to the railroad. Passenger trains cause per kilometer of track per year up to 12 tons of garbage and 250 kg feces.

5. Magnetic trains cannot change the situation meaningfully (perhaps only in Europe). In addition, the construction of such stretches and the disposal and reconstruction of extant sections causes enormous costs that no European country can afford.

Air traffic:

1. is the most dangerous means of transportation environmentally with the highest energy use. The total emission of dangerous substances into the atmosphere reaches 30-40 kg per 100 passenger kilometers flown. The highest amounts of dangerous substances produced by aircraft are concentrated close to airports, i.e., close to large cities, during low flight, and during acceleration. At low and middle altitudes up to 5000-6000 m, air pollution caused by nitrous oxide and carbon monoxide remains for several days. It is washed away by moisture to form acid rain. At high altitudes, air traffic is the only source of air pollution. Dangerous substances remain in the stratosphere much longer - ca. one year. The toxicity of

the emissions from modern jet plane corresponds to 5-8 thousand cars while it uses the same amount of oxygen to burn kerosene as more than 200,000 people use to breath. Several thousand acres of pine forests or an even larger surface area of plankton are needed to reproduce this amount of oxygen in the atmosphere.

2. Due to natural cosmic gamma radiation, every passenger in a flight lasting several hours is subjected to radiation of several thousand micro-roentgen. The radiation level inside an aircraft flying at the normal altitude for passenger flights is 300-400 µR/h as compared to the maximum allowable value of 20 µR /h.

3. Ground is removed for the construction of airports that is comparable to the construction of railroads and roads for auto traffic. However, this land is very close to cities and therefore has much more immediate value.

4. Air traffic is one of the biggest causes of noise, especially around airports. It also causes large electro-magnetic emissions through its use of radio location at radar stations.

5. Air traffic is the most expensive means of transportation. A modern aircraft by Airbus costs ca. $ 100 million, while the costs for a large international airport exceed $ 10 billion.

This short analysis demonstrates beyond a doubt that we need to search for new chances to completely change the nature of traffic. One of these possibilities is an invention by an engineer from Belarus, Anatoly Unitsky. He first published this idea in 1982 in the former USSR but found no official support there. Unitsky was already on the KGB's list of "suspected individuals" before that publication. The attempt had already been made at the end of the 1970's to discredit Unitsky because of his ideas about geo-cosmic industrialization (see section 18.2) that sharply contrasted to the "triumphal politics" of accessing the closest areas of outer space with rocket technology.

Let's now reinvent Unitsky's invention based on the method of the integration of alternative systems. The alternative system 1 has high speed but is not very maneuverable (railroad) while system 2 has lower speed but is much more maneuverable (automobile). Safety and a sufficiently high speed are also important for traffic between cities. Here our basis is therefore the railroad. On the other hand, automobiles are safer when deviating from a structured path because they transport fewer passengers. The most important technical advantages of the automobile are that it can consist of several modules and it is much smaller than a train.

These considerations lead to the first statement: *traffic must be based on modules with a small number of passengers that move at high speeds.*

Of course, there is also the problem of ground use and the construction costs of new lines. High speeds require extremely level and straight structures. Railroad tracks fulfill this requirement best. The high weight of trains means that tracks are built on strong foundations that are not exactly environmentally friendly and that cost a lot. The requirement of a module concept for traffic leads to a second statement: *track structures can be very light constructions above the ground with the advantage that they are extremely level, straight, and relatively independent from the topography of the construction site.*

Module traffic must definitely and without exception have an electric drive (see exercises *14-15*). This leads to the third statement: *If the automobile is to retain a* *place in traffic in the future, then it must be transformed into an electric car and be integrated into a new traffic structure.*

This is the concept of the STS:

The basis for the STS are two special electrified track strings that are isolated from each other and supported at a height of 10-20 meters (or higher, if necessary) by columns. A high speed module - an electric automobile - moves on four wheels along a string. The extremely level and solid construction of the strings means that speeds of up to 250-350 km/h can be reached with the STS and theoretically even 500-600 km/h would be possible, or even 1000 km/h in a vacuum tube. The elements of the strings pull against each other with 300-500 tons of tension and are stabily grounded in anchor supports at a distance of 1-3 kilometers. Columns are separated by 20-100 meters.

The electric modules can carry up to 5000 kg and up to 20 passengers (fig. 15.19, 15.20, 15.22 and 15.23). Power is supplied by the special tracks with an electrified surface in contact with the wheels. With the use of nuclear energy sources, the track surfaces and modules would need no electricity. The lines of the STS can be easily coordinated with special power lines, even with optic fibers to wind and solar power facilities.

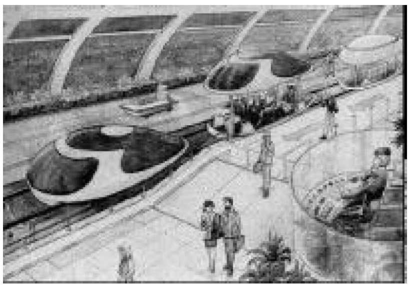

fig. 15.19. Train station of a string transportation system

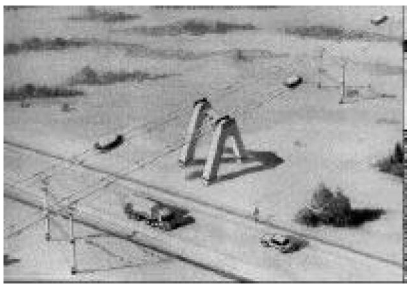

fig. 15.20. STS runs over a highway

The strings of the STS are constructed from high quality steel cables with a diameter of 1-5 mm. These cables are then bundled together and installed with the least possible rounding in the hollow spaces of the tracks (fig. 15.21). The tracks are mounted in such a fashion that the upper surface of the tracks are kept perfectly level with self-hardening materials such as cement or epoxy after the strings have been firmly mounted into the track's hollow spaces. This is how the surface of the track on which the wheels move doesn't sag and has no gaps.

Most of the time, the columns of the STS are spaced 25-100 meters apart. The STS has been projected so that the columns carry only vertical loads. This means that the load is relatively light - 25 tons with a span of 50 meters. The towers of power lines are subjected to a similar load and are therefore similar in the use of materials to the columns of the STS. The maximum horizontal load along the entire line effects only the 2 anchor supports at each end of the stretch: per side 1000 tons for a double track line and 500 tons for a single track.

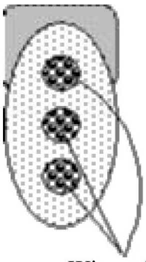

fig. 15.21. Construction of the string-tracks

The structure of the STS is extremely solid. In a span of 50 meters, the static curve of the track in the middle between two supports is a maximum of 12.5 mm with a concentrated load of 5000 kg/s or 1/4000 of the distance between the supports. As a comparison, bridges are projected today that allow 10 times more sag in the middle - 1/400 of the length of the bridge. The dynamic sag of the STS under moving loads is even less - up to 5 mm or 1/10000 of the distance between supports. This kind of stretch is more level for the wheels of a transport module than the salt lake on which a car reached super-sonic speeds - 1200 km/h - for the first time at the end of the 20^{th} century.

The highest speeds of the STS are not influenced by the levelness or dynamics of vibrations on the track and there are no problems with the friction contact "wheel – track". Only aerodynamics plays a role. This is why special attention was paid to aerodynamic questions. This produced unique results without analogy in modern high-speed traffic, not even in air traffic. A modern passenger module's coefficient of aerodynamic resistance was measured in a wind tunnel at C_x=0.075. Measures are planned to reduce this coefficient to C_x=0.05-0.06. Thanks to this low air-resistance, a drive that puts out 80 kW can push a passenger module with 20 seats along at 300-350 km/h, with 200 kW at 400-450 km/h, and with 400 kW at 500-550 km/h. Here the mechanical and electro-mechanical losses are minimal because the degree of effectiveness of the steel wheels is 99% and of the wheel-motor complex 92%.

The reliability of the structure of the stretches and the supports of the STS as well as its building construction is at the level of span bridges with similar construction principles. However, the strings of the STS are much better protected against weather and mechanical influences than the cables of bridges.

Economically speaking, it is estimated that the mass-produced cost of a two track line of the STS with infrastructure (train stations, stations, freight terminals, depots, etc.) in millions of $ per km would be: 1-1.5 on a level surface, 1.5-2-5 in mountains and for lines on water, and 5-8 under water or underground with special tunnels.

The construction of a transportation module is simpler than a car. A mass-produced module would cost $20-40,000 or, in a unit with 20 seats, $1-2,000 per seat. In comparison, other high-speed transportation systems cost per seat: aircraft - $100-200,000, magnetic train - $100-200,000, high-speed trains $20-30,000.

We can now summarize the extremely interesting technical-economic and ecological characteristics of the means of transportation:

1. A lot of land is not needed to construct the string-lines: 150-200 times less than for roads or railroad tracks. It is not necessary to dig trenches or mounds and forests and extant buildings are only slightly influenced or disturbed. This is why it's easy to integrate the STS into the infrastructure of cities and also into areas with difficult natural conditions: in perma-frost, mountains, swamps, the desert, into areas with water (rivers, lakes, ocean channels, ocean shelves, etc.).

fig. 15.22. Unitsky's STS at the mountains

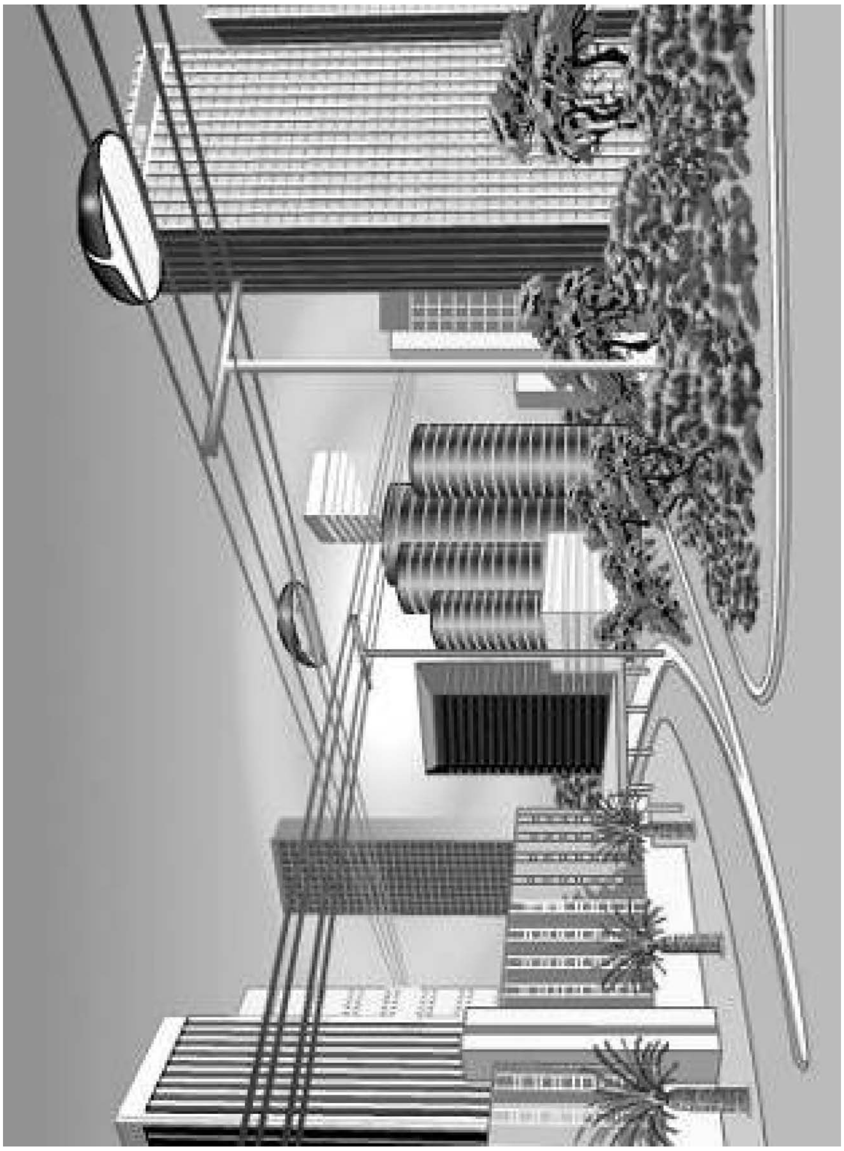

fig. 15.23. Unitsky's STS in the town

2. The stability of the system is increased in natural catastrophes such as earth quakes, avalanches, floods, storms, and under poor weather conditions such as mist, rain, ice, snow, sand storms, high heat and extreme cold, etc.
3. Compared to all other known high-speed transportation systems, the STS is ecologically better, more economical, has better technology, and is safer.
4. The minimal material use and the successful technology of the STS's lines means that it is 2-3 times less expensive and 8-10 times faster than the railroad, 3-4 times faster as a double string or 2-3 times faster as a single string than highways, and 15-20 times less expensive than a magnetic train. Travel with the STS will be extremely inexpensive: $5-8 per 1000 passenger/km and $2-5 per 1000 tons of freight/km.
5. The STS can be built as a technological or special string for freight, passengers, or both. Connecting lines with low maximum speeds (up to 150 km/h), middle-speeds (150-300 km/h), and higher speeds (300 km/h plus) can be built. Up to 500,000 passengers and 1 million tons of freight can be transported daily. The transport capacity exceeds that of a modern oil pipeline, even though STS lines are cheaper. The cost to transport oil with the STS would be 1.5-2 times less than with a pipeline. The STS could be used to transport garbage out of large cities, raw materials from their source to processing plants, coal to power plants, and oil from storage to processing and refining. Hundreds of millions of tons of pure drinking water could be brought to thinly settled regions of the world over distances of 5-10 thousand kilometers, etc.
6. The total cost of an STS line "Paris (London) – Moscow" would be $5.7 billion (the length of the line is 3110 km). The line and infrastructure would require $5.2 billion and the moveable elements would cost $0.5 billion. The line would pay for itself in 5-7 years. The cost of a trip from Moscow to Paris would be $32 per passenger and it would take 7 hours and 10 minutes (at a distance of 2770 km and with an average speed of 400 km/h). In ten years, this line would create revenues of ca. $2 billion per year.

Many variations of the construction of string-lines are possible that could be strategically and geopolitically important for virtually every country in the world.

The STS implements the following TRIZ principles (fig. 15.24).

The application of the STS makes a radical reduction in the number of flights up to 2000 km possible. Aircraft would only be needed for ocean flights longer than 2000 km. The use of roads could be drastically reduced and traffic jams on highways could be eliminated. The railroad could be reconstructed (shortened) completely so that it still handles heavy transports on major lines.

Here we're paying a lot of attention to the development of transportation systems because traffic is one of the most essential current problems that needs to be solved quickly and decisively.

As an exchange (transport) of material and human resources, traffic and communication are necessary conditions for individual and collective well-being. It is a means for human communication in a territorial and intellectual space, a way of life, and one of the most basic cultural values - a criterion for the level of a *life, and one of the most basic cultural values - a criterion for the level of a country's civilization.*

Nr.	Principle	Application
02	Preliminary action	The stations of the STS are in the center of cities as opposed to airports, for example.
03	**Segmentation**	**Small high-speed modules instead of heavy trains with high energy use**
04	**Replacement of mechanical matter**	**Improvement of the mechanical structure – extremely level stretches**
05	**Separation**	**The entire line was separated out above buildings and the ground or down under the ground or water!**
06	Use of mechanical oscillations	The frequency of the string's vibrations is increased to extreme values to reduce the time they require.
08	Periodic action	Freight modules move between the passenger modules.
11	**Inverse action**	**Fast modules on light string-tracks instead of heavy trains and dug up stretches**
12	**Local property**	**The string-track is ideally level; the line can run at an optimal height between connected points.**
19	**Transition into another dimension**	**The line was laid up along higher coordinates.**

fig. 15.24. Application of several TRIZ procedures in the invention of the STS

The unsatisfactory condition of traffic networks leads to disruptions in normal economic functions and in production in mixed economic branches. It leads to enormous temporal and material losses in resources, to higher prices in goods and services, to a reduction in the standard of life of the population, and to problems in the development of education and culture. It causes slow downs in foreign trade and tourism, increases in ecological destruction, problems in dealing with the results of natural catastrophes, and increased death rates in the population.

Exercises 14 – 15

35. Automobile. Use the meta-models "poly-screen" and "mono-bi/poly-mono", the "method of the integration of alternative systems", and "Lines of system technical development".

35.1. Do you know alternative energy sources for cars? Examples are Professor Guliya's swing-wheel, engines with compressed air, hydrogen engines ... Continue with the list.

35.2. Can you suggest a more economical engine that uses other physical-technical effects, such as piezo-electrical ones?

35.3. These are alternatives for the development of the module(s) of Unitsky's STS:

- a cabin to transport passengers or freight;
- a platform to transport cars with passengers;
- an integrated module-automobile that travels independently on the track and then drives off to park like a normal car;
- invent further!

35.4. How would the ideal car look if we use the STS to make it unnecessary to drive for more than 100 km at more than 50 km/h?

36. Railroads and highways. What could change in these modes of transportation if the STS is developed? Would they only be useful to transport loads? Use the meta-models "poly-screen" and the "method of the integration of alternative systems".

37. Air traffic. Safe! Environmentally friendly! Economically sound! Where are the alternatives here? Do we really need super-sonic aircraft to fly at an altitude of 30 km at speeds of 10-12,000 km/h from Moscow to San Francisco or from Paris to Sydney in 2 hours? Or will "Zeppelins" be better for the future?

38. City traffic. What is better, cars for 100–200 people or individual means of transportation? Moving pedestrian zones or light individual flying machines? Which way is best in the city for pedestrians: underground, on the ground, 10-20 m high, or above buildings at heights of 20-100 m? Keep in mind that old and new systems can exist parallel to each other.

39. Oil transport. There are catastrophes with oil tankers and pipelines. We know that there are tankers that transport loads using modules. Is this a solution for the problem of safety and environmental impact? Is the STS the ideal solution to do without above ground pipelines completely? Can we combine the ideas of a module-tanker with the STS's modules?

40. Water. Where can we find unlimited clean, high quality water?

41. Forests. The development of computer technology has increased the use of paper instead of reducing it and has helped drive the destruction of forests – the lungs of our planet. Can we reduce the number and size of the newspapers that are published? Can we stop printing books and using paper for packaging? Or… Use a more constructive spirit to invent further.

42. Electro-energetics. There is so much solar and nuclear fusion energy on the earth. There is so much electrical thermal energy and kinetic energy in the atmosphere and oceans. But, energy sources on the earth are still insufficient. In addition, the earth's atmosphere continues to be polluted and warmed by the burning of fossil fuels, especially oil, just to create energy.

43. Living in the city. In the city there is noise, dust, traffic, and very little connection to nature, and stress with the neighbors. How and where can people shape their living space in the future? Start with the parameter that it shouldn't take more than one hour to travel from the center of a large city 100 km out and back. And it is very important that we live in harmony with nature!