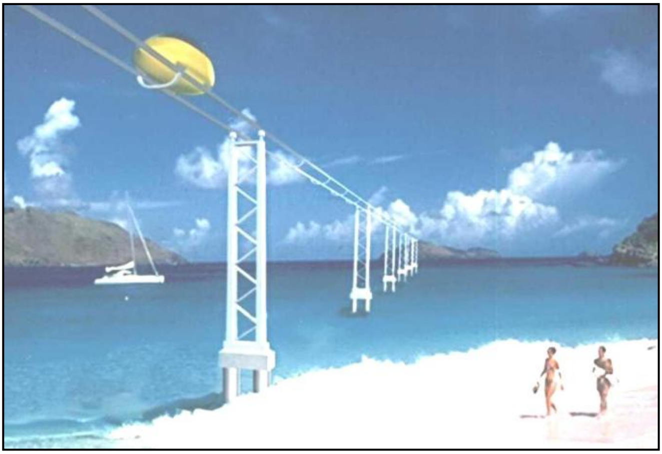
FOUNDATION "YUNITRAN"

TECHNICAL OFFER

STRING TRANSPORT LINE

" Nahariyya - Tel Aviv - Khan Yunis "
(on the shelf of Mediterranean Sea along the coast of Israel)



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1. String Transport System

1.1. Principal Route Diagram

The String Transport System (STS) is a string rail route to carry electrical wheel vehicles. A specific feature of the route are the strings within the rails stretched to the total force 250 tf per rail. The strings are rigidly secured to anchored supports spaced every 500...2,000 m, the route structure being carried by intermediate supports spaced every 25...100 m. The strings within the rails deflection to about 5 cm, with the deflection increasing to the span centre and reducing to zero over the supports. Hence, the rail head maintaining the vehicle wheel statically has no deflection or joints throughout its stretch. While remaining highly straight and rigid the STS rigid structure promises to allow speeds of 350…400 km/h and more in the future. Appendix 1 demonstrates design, technological and other STS features in more detail.

An international invention application "Linear Transport System" has been filed with # PCT/IB94/00065 dated 08.04.94 under which an international patent search has been accomplished, it has undergone expertise and initial patents have been obtained in the Russian Federation and South African Republic (the patenting is underway in 20 countries). The inventor also filed applications for industrial samples of the vehicle and string rail for legal protection of the inventions.

1. 2. Line Route Diagram

Fig.1 shows the route line diagram. The optimum spacing between intermediate supports is: for land areas - 50 m, for sea areas - 100 m. This spacing can be reduced to 10...20 m along the stretches with more intricate profiles or increased to 200 m. When the spacing is larger (the modern materials allow to have the spacing 5,000 m and more) the route structure will be supported with ropes or cables (like suspended bridges).

Considering that the STS is easily adaptable to the terrain profile it can run along the shortest cuts or straight. When necessary, the route structure can be curved both vertical and horizontal planes. For comfort (so that passengers are not affected by overloading along curved stretches) the curvature radii should be at least 20...50 km.

The STS line will pass along the shelf of Mediterranean Sea with average depth of 10 m, i.e. at a distance of 500...2,000 m from the coast and, of course, outside territories of beaches, zones of the people's rest and relaxation, situated on the sea. If it's necessary, the line can be moved off to the sea depths up to 50 m, at a distance of 4...12 km from Israel's coast. In this case, STS can serve as the first defensive belt of Israel against the aggression of potential enemy from the Mediterranean Sea (the line will be equipped with systems of detection and neutralization of aggressor's ships and airplanes).

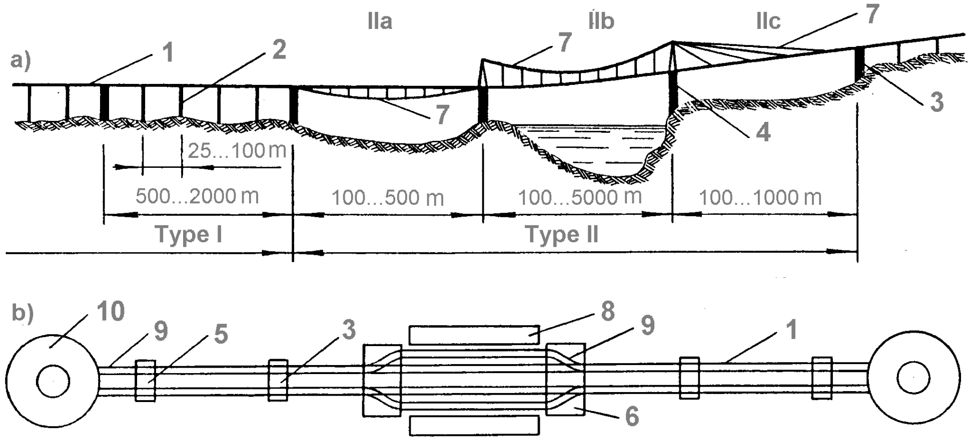

Fig. 1. Route line diagram:
a) side view; b) top view; 1 – double-track structure; 2 – support; 3, 4, 5, 6 – anchored supports, correspondingly: intermediate; pylon; end; with switch point; 7 – supporting rope; 8 – intermediate station; 9 – part of the route constructed with normal rails (railway type); 10 – end of route station.

Big navigable spans with length of 500 m (20 pieces) and 250 m (20 pieces) will be created on the STS line in the area of seaports, along the routes of large-capacity sea ships. The line structure at these areas will be lifted up to the height of 50...100 m above sea level (the type of span construction - II *b*, see Fig. 1).

The main transport line, passing over the sea shelf along the coast (its length - 210 km), will have several branches to all large cities situated not far from the coast of Mediterranean Sea (Nahariyya, Akko, Haifa, Hadera, Netanya, Tel Aviv, Ashdod, Ashgelon, Gaza, Khan Yunis). The average length of a branch - 30 km. Every branch will have the system of special switches.

1.3. Route Structure

Depending upon the span the STS structure is divided into two typical types: I - common design (the span is up to 100 m); II- additional supporting cable structure (the span is over 100 m) with the cable arranged: (*a*) underneath; (*b*) above with parabolic deflection (*c*) above as guy ropes.

1.3.1. Rail-String

Fig. 2 shows the rail-string design. Each rail head is a current carrier electrically insulated from the carrying structure and other supports and rails. Each rail has three strings from wires 1...3 mm in diameter stretched with the total force 500 tf for the route structure and 1000 tf for the double-track route. The wires in a string are encapsulated in a protective shell between the supports, they are not linked together being arranged in a special corrosion resistant composition. The strings are rigidly secured in the anchored supports. Appendix 1 gives a more detail description of the design.

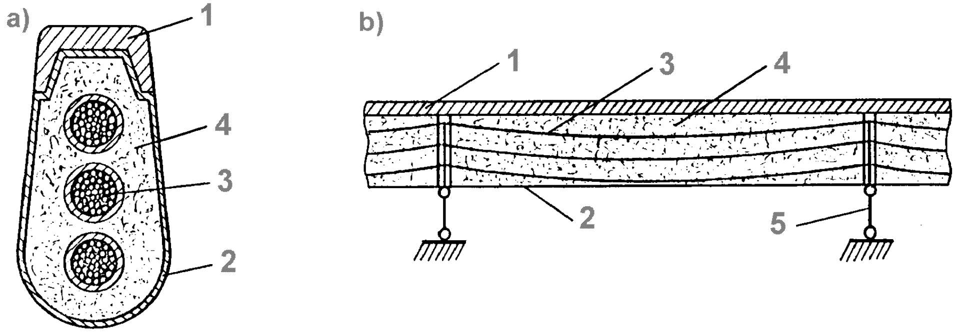

Fig. 2. Rail-string design:
a) cross section; b) lengthwise section; 1 – head; 2 – body; 3 – string; 4 – filling; 5 – support.

1.3.2. Carrying Cable

Like the strings in the rail, the carrying cable is made from heat resistant steel wires enclosed into a protective watertight shell. The free space in the cable is filled up with a corrosion resistant filler. The longer the span the greater is the cable diameter. For example, due to a low material consumption for the route structure and its light weight, the cable 100 mm in diameter carries the STS span 1000...1500 m long.

1.3.3. Route Structural Rigidity

The STS route structure requires little materials, less than 100 kg/m for a one rail-string, still allowing to achieve a highly strong tensioning of the strings. It has a typical small deflection of the structural elements both under its own weight and moving vehicles (see Table 1)

Table 1

Deflection of the STS Structure under its Own Weight

Span, m	Static (erection) deflection of structural elements			
	string in rail		guy cable	
	Absolute deflection, cm	Relative deflection	Absolute deflection, m	Relative deflection
25	1.6	1/1600	-	-
50	6.3	1/800	-	-
75	14.1	1/530	-	-
100	25	1/400	0.25	1/400
250	-	-	1.56	1/160
500	-	-	6.25	1/80
750	-	-	14.1	1/53
1000	-	-	25	1/40

The deflection figures in Table 1 determine the height of the STS spans, their sliminess and aesthetic appearance. In any case, the STS structure is much slimmer than bridges, road arteries, viaducts and other similar structures of highways and railways as well as girders of monorails.

The strings will have a deflection after erection concealed within the rail. When the span is 25...50 m the string will have the relative deflection 1/1600...1/800 and the absolute deflection 1.6...6.3 cm in respect to the span. This deflection is easily accommodated within a specially designed rail 20...25 cm high.

In any case, the above deflections appear after erection without affecting the smoothness of rail heads which are very rectilinear when unloaded. The route curvilinearity in the vertical plane appears under a moving load, it is induced by winds and moving vehicles in the vertical plane. The maximum static deflection produced by a vehicle (2,500 kgf) braked in the span centre is will be within 1/800 for the rail and 1/2400 for the span supported by the cable. Dynamic deflection at speeds over 200 km/h will be significantly less than those indicated above (within 1/10,000...1/2,000, or within 5...15 mm in absolute figures). These figures prove that the STS is more rigid (in respect to the rolling stock) than railways, bridges and highway loops which have a greater estimated deflection under nominal loads.

The structural features of the route structure and the modes of movement of the vehicles have been investigated and defined in order to eliminate resonance phenomena in the rail-string. Moreover, oscillations will appear and remain behind a moving vehicle, they will attenuate within 0.1...0.5 s, next vehicles will run along undeflected, perfectly smooth rails.

Variations of temperature-induced deformations of rail-strings are compensated by temperature strains, hence, variations of the span relative deflection will insignificantly affect the rail-string smoothness when the span between supports remains unchanged. The string will not have any deformation seams along its stretch, in response to temperature variations it will behave like a telephone wire or power transmission lines which are also suspended with deflection between supports without joints for several kilometres, like the strings in the rail. Temperature variations from –50 ^{o}C (winter) to +50 ^{o}C (summer) will cause relative deflection variations within 1/10,000 basically without any effect upon the route smoothness.

Elongation strains in the string will add approximately 500 kgf/cm^2 in the summer and deduct the same 500 kgf/cm^2 in the winter. A smaller temperature difference will produce a milder strain deformation of the rail-string.

Taking into account a highly streamlined design of the STS and the vehicles, the relative deflection of the STS route structure under the influence of lateral winds blowing with the speed 100 km/h will amount to 1/10,000...1/5,000 without affecting the transport line's performance.

The route's smoothness will not be affected by the ice appearing on the STS structural elements, for example: at winter or in mountains. Yet, considering small cross section, stream lining, high- and low-amplitude oscillations and other factors inhibiting icing, the latter can be fully eliminated. For example, special modules equipped with gas turbine engines to melt ice film with a hot air stream can be sent regularly along the route during the most risky winter periods.

1.4. Supports

The carrying structure of the supports comprises two basic types: (a) the anchored supports to undertake horizontal forces produced by string and cable elements (Fig. 3); (b) carrying supports to undertake just the vertical load of the STS route structure (Fig. 4).

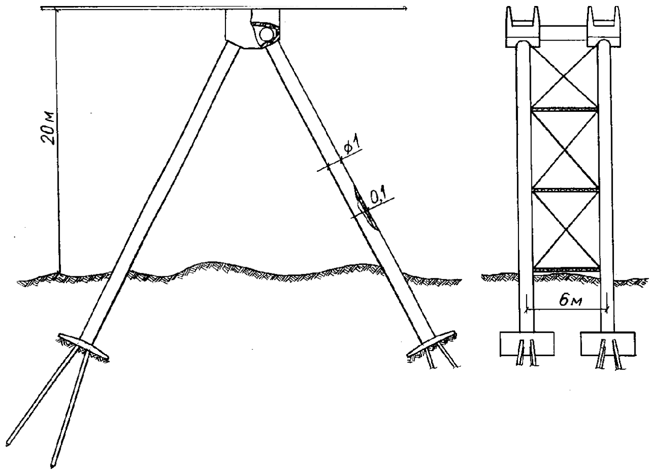

Fig. 3. Anchored support of double-track STS route

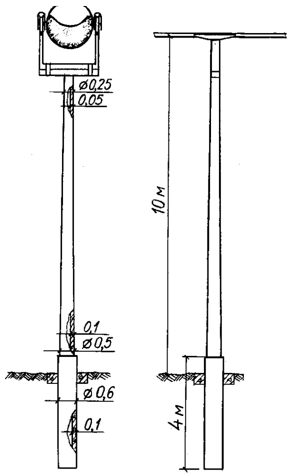

Fig. 4. Small height intermediate support of single-track STS route

The anchored supports can be spaced at 0.5...2 km depending upon the terrain relief (on land areas) and sea depths. The maximum horizontal loads experienced just by the terminal anchored supports (they are affected by one-way loading): 1,000 tf for the double-track and 500 tf for the single-track routes.

The intermediate anchored supports (they comprise over 90% of the total number) will not experience any significant horizontal load in operation, because the forces acting upon the support from each side will become mutually balanced. In accordance with the terrain relief the carrying supports will be spaced at 25...100 m (the optimum span is 50 m). The minimum vertical load upon the support (together with the moving weight) is 10 tf (the span is 20 m), the maximum load is 25 tf (the span is 100 m).

On land areas, practically on any type of relief (including mountains), the STS line can be situated on supports with average height of 25 m. Distribution of heights of supports is shown in Tab. 2. The optimal distance between carrying supports - 50 m, between anchored supports - 1000 m.

The average height of supports on sea areas - 35 m, e.g. 10 m of this value is for underwater part. Under the circumstances, the STS line structure will be situated at the height of 25 m above sea level, that is enough for sailing and small ships to pass. The optimal distance between carrying supports situated on the shelf - 100 m, between anchored supports - 2,000 m.

The supports are described in Appendix 1 in more detail.

Table 2

Determination of Average Tallness of Supports on land areas

Tallness of supports, m	Proportion of the supports in their total number, %
5	5
10	8
20	55
30	15
40	10
50	5
100	2
Total: average tallness of supports -25 m	100

Fig. 5-6 demonstrates the versions of single-track STS routes and their supports for various geographic conditions.

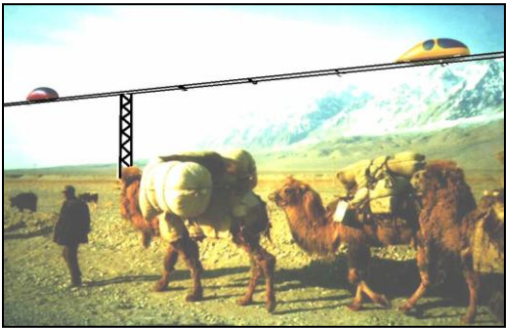

Fig. 5-6. Versions of single-track STS routes for various geographic conditions.

The carrying supports experience slight vertical, transverse and longitudinal loads (for example, the transverse loads appear during braking, they are transmitted by the rail-strings to the anchored supports. Therefore, the supports have typical small cross-sections, light foundations occupying little area and requiring little earthwork. It is specifically significant not to encroach upon the proprietary rights of land owners which may create serious problems. The STS can be run in a single span (5,000 m long) 50...100 m high over expensive land plots with economical land use. Since the STS is a "transparent" structure (almost without shadow) it will be ecologically clean, with a low noise level, it can run over residential areas, game preservations, parks, etc.

Designs of unified modular STS supports have been developed: short (5…15 m), average (15…25 m), tall (25…50 m) and supertall (50…100 m) which are unique in their little consumption of materials and they are highly easy to fabricate and erect.

1.5. Vehicle

The passenger vehicle accommodates 10 persons (during peak hours), a cargo vehicle can carry 4,000 kg load, the motors are 80 and 40 kW, respectively, with the energy delivered through wheel which contact the current conducting rail heads (the right and the left) allowing to reach the speed 300 km/h. The drive can be designed as two motor wheels 40 kW each. A perfect shape of the vehicle body has been selected with the aerodynamic resistance factor C_x=0.075 (the model was tested in the aerodynamic tube) allowing to minimise the aerodynamic losses and noise at high speeds. Further work on the vehicle body shape provided reduction of the aerodynamic resistance factor C_x to 0.05…0.06.

To reach 400 km/h the power of the motor of the passenger vehicle should be increased to 200 kW and to 400 kW to reach 500 km/h. For the cargo vehicles to reach the same speeds it is enough to have a motor which is twice less powerful than that of the passenger vehicle (the front surface area of the cargo vehicle is two times less).

The vehicle can operate as a routed taxi from the boarding station to the destination without any driver steered by the on-board computer. The latter is controlled and guided by line and central computers. The vehicle is described in Appendix 1 in detail.

Fig. 7 shows the vehicle of the class "lux" long-range (with toilet).

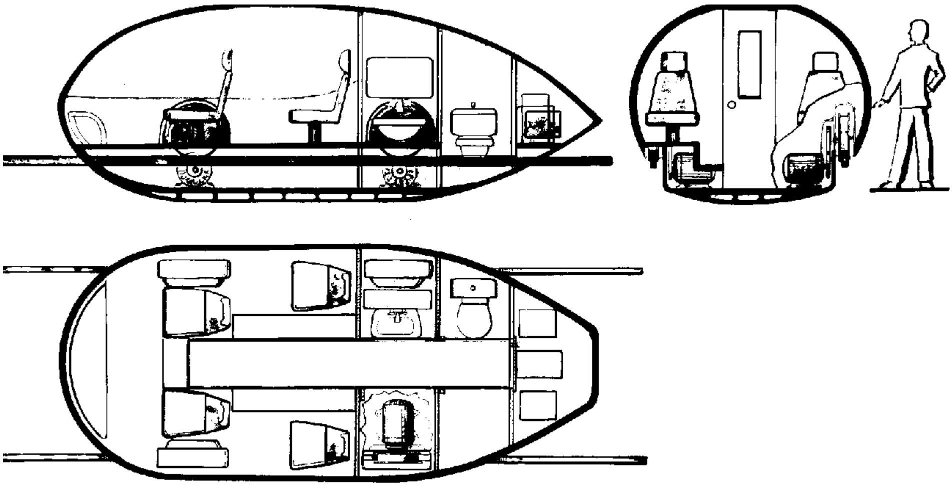

Fig. 7. Long distance travel vehicle for four passengers.

1.6. Passenger, Cargo Terminals and Stations

Terminals will be circular with moving (rotating) platforms (Fig. 8) or floors. The terminal diameter is about 60 m which can be increased up to 100 m or more where passenger traffic is greater (over 100 thous. passengers during 24 h).

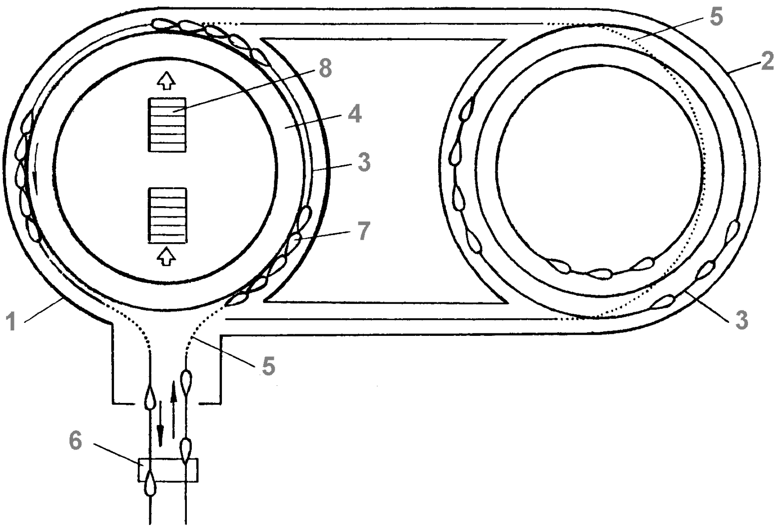

Fig. 8. Station:
1 – station building; 2 – garage-workshop; 3 – ring-way; 4 – ring-way mobile platform; 5 – switch point; 6 – end anchored support; 7 – vehicle; 8 – entrance (exit) to the station.

Intermediate stations with significant passenger traffic will have switches and sheds to pass the vehicles irrespective of the main schedule (Fig. 1). The stations with smaller passenger traffic are made as open platforms along the route. The boarding (landing) of passengers is effected after braking individual vehicles with vacant seats.

Circularly shaped cargo terminals will be equipped to load and unload automatically cargo modules. They will be compact with extensive handling facilities employing a unique process of handling operations and specially designed containers for fluid, bulk and piecemeal cargo. For example, a terminal 100 m in diameter will be capable to handle about 100 thous. tons of oil (or oil products) a day (36.5 mln tons a year) or much smaller in size than a sea harbor of the same handling capacity.

Individual consignments, such as passenger cars, can be transported on open platforms, though it may require to increase the power of the motor of a cargo module 2...3 times. Thus, passengers can get from one city to another during highway rush hours and with unfavorable weather conditions without leaving their cars.

1.7. Management of Passenger and Cargo Traffic

1.7.1. Boarding and Landing

Upon entering into the terminal the passenger sees a lighted sign on each vehicle (the sign can either be on the vehicle wall or on the terminal wall as a moving line of information) indicating the destination name, for example, "the terminus". If the required destination is not indicated the passenger can board a vacant vehicle and press the "terminus" button (inside the vehicle). Passengers will have 0.5...2.5 min to board if the moving platform with the vehicle on it has the speed 0.5 m/s and the circular route is 50 m in diameter. After the door is shut (automatically or manually) the vehicle is released from the moving platform, the switch transfers it to the track line. In case the door has not been shut or the boarding has not been completed or there no passengers the vehicle is returned to the second round on the platform. Similarly the passengers land at their destination in reverse order. In its general implementation it resembles the handling of baggage along circular conveyers at modern airports. If necessary, some vehicles may be directed to workshops in a separate building or at another floor of the terminal.

1.7.2. Cargo Handling

Cargo is handled automatically at cargo terminals. Consignments are delivered to the terminal and forwarded to a consignee by other means, such as an oil pipeline. Large consignees and consignors, such as oil refineries, will have their own terminals.

Full containers are loaded into the cargo modules which are then marshaled into trains and directed to the transport line. At destinations containers are removed from modules and directed for unloading, their places are occupied by empty containers or containers with other cargoes. The capacity of a container is 1000...4000 kg. Each container is accompanied with an electronic card to be read by the on-board computer to enter the nature of a consignment, its weight, conditions of transportation, destination, consignee, etc.

Passengers can continue to travel in their cars on a special open platform or they can commandeer to dispatch their cars ahead of them or to follow them in an open cargo module and travel in the passenger vehicle.

1.7.3. Traffic

Vehicles are grouped together electronically into trains of five vehicles with the space between them 100 m. The control system along the entire route maintains the same speed of the vehicles in the train and the spacing between them. To maintain the traffic 1,000 passengers per hour one train of five vehicles should leave the terminal every three minutes. The average spacing between the trains will be 20 km at a speed of 400 km/h. This spacing is sufficient for manoeuvring when passengers board or land at intermediate stations. The running trains will be grouped at boarding stations and by adding vehicles at intermediate stations (at the head or at the tail). Therefore, the control system will both send vehicles and control their location co-ordinating their "synchronisation" in time. Some stations may have special marshalling facilities to accumulate vehicles. The speed will be set from 200 km/h (steep ascents) to 400...450 km/h along horizontal stretches and descents. Line and central computers will control traffic by accumulating information about the location, speed, destination and condition of all major units (the running gear and the drive, in the first place) of each vehicle. Modern control software allows to arrange the transport traffic of STS vehicles with 100-percent safety without man's involvement.

A system similar to the one developed in Japan for the self-controlled Mitsubishi car can be employed to control the STS vehicles. Each vehicle will have three on-board TV, infrared and ultrasound systems running simultaneously. The on-board computer will receive signals from the vehicles ahead to analyze and adjust the proper speed and the spacing. Also, there will be mutual information exchanges and with the line and central computer systems to check the location, speed, condition of the route structure, supports, switches, irregularities, track defects, etc. The on-board computer system will employ microprocessors to process the data from built-in sensors, TV and IR cameras, mechanical means. Relevant commands will be issued for various executive mechanisms. The operations of manoeuvring are automatically co-ordinated with the route line computer system in order not to affect the transport traffic.

1.7.4. Travelling Time

Table 3

Time spent by a passenger to travel from Nahariyya to Khan Yunis (215 km)

No.	Transportation process	Time, min
1	Waiting for a vehicle to arrive	1
2	Boarding	2
3	Waiting until start	1
4	Joining the main traffic	1
5	Acceleration to 400 km/hour	3
6	Traffic along the route	30
7	Decelration	2
8	Driving into the terminal	1
9	Landing	1
10	Unforeseen time losses	3
	Total:	45

1.7.5. Route Traffic Capabilities

When trains comprise 10 ten-seat vehicles moving with the speed 400 km/h with the interval 30 seconds, the traffic of a single line during peak hours will amount to 12,000 passengers/h and 24,000 passengers along the route (with two oppositely directed lines (or 576,000 passengers every 24 hours). There is a margin to increase the traffic without adding more lines.

The minimal distance between cargo modules along the line is 50 m (50...100 m is the minimal urgency deceleration by throwing out a braking parachute), hence the ultimate traffic capacity of a single line at a speed 300 km/h is 24 thous. t/h or 576 thous. t/day (210 million t/year). The maximum traffic capacity of a double-track line is 48 thous. t/h. 1,150 thous. t/day, 420 million t/year.

The actual scope of cargo and passenger traffic will be one order of magnitude less because the route will operate at its 10-percent capacity, it will promote the reliability and safety of the transport system in operation, in the long run.

1.8. Safety and Reliability

1.8.1. Safety at Terminals

The safety of passengers is achieved by the synchronisation of speeds and the circular terminal platform, for example, by joining them with mechanical means. The platform should move with the speed 0.3 m/s for the passenger traffic 2,000 passengers per hour with a full rotation during 8.7 min (when the outer diameter is 50 m).

Safe electrical voltage (12 or 24 Volts) or batteries in vehicles, or electrical current of the same voltage supplied through the rail track will exclude shock hazards.

1.8.2. Transport Line Electrical Safety and Reliability

Safety is ensured by a relatively small voltage in the line (within 1,000 v), insulation of current carrying rail heads and supports and by non-conductive vehicle bodies made from composite materials. Hence, in case a vehicle misses the rail track it will not produce any short-circuiting between rail heads.

When the traffic reaches 1,000 passengers per hour along a leg 100 km long, 25 vehicles will run simultaneously with the total power of motors 5,000 kW. No additional transmission lines to supply the STS and its infrastructure, because the rail-string will allow to transmit the electrical power over 10,000 kW (up to 100,000 kW if it has a special design). Therefore, the STS should be connected to the existing grid every 100...200 and more km.

1.8.3. Traffic Safety

Traffic safety is achieved by failure-free operation of all the systems effective to maintain the routine mode of traffic: the computerised control means, reliable electronic systems, communication lines and measuring instruments, executive mechanisms of switches and drive controls and the braking system, reliable mechanical members of the route structure, STS supports, etc. A hundred-percent safety of the traffic processes is evidenced by the experience of operation of high-speed railways in the world. For example, high-speed railways in Japan have transported over 5 billion passengers during 20 years of operation without any accidents or casualties. In case of power failure each vehicle is equipped with a battery and an emergency starting motor which will deliver the vehicle at a slower speed to one of the stations or emergency stop platforms on each anchored support, i.e. after every 1,000 m on land areas and 2,000 m on sea areas.

1.8.4. STS Structural Reliability and Functioning

STS cable and string elements of rails and carrying structures are exposed to the utmost strain. Since they are in a corrosion resistant medium in a special shell and in a mechanically strong body protecting them against external effects, their service life can amount to hundreds of years. Also, the travelling load alters the stress-strain state of these elements only by one per cent (see Appendix 1, p. 8) this state remains basically unchanged during the entire period of operation extending the service life and saving operation costs.

Since the string elements are located in different remote places (mutually isolated wires in the strings of the left and right rails, the one-way and back lines, the upper and lower strings, etc.), the probability that they snap simultaneously is close to zero, even in case of disasters, such as earthquakes, floods, hostilities, etc.). Even when 90% of carrying wires snap, the structure will not collapse, unlike other structures, such as bridges, highway loops, viaducts, modern skeleton buildings, etc.

The STS route structure remains highly durable even when destroyed by terrorists. A support is secured to the route structure with a special unfastening mechanism which releases it making just the rail-string span longer and increasing its corresponding deflection. It will not destroy the integrity of the route even in the case when all the intermediate supports between adjacent anchored supports are destroyed.

STS coming along the sea shelf, will be less vulnerable than if it is situated on land. It is due to more difficult admission for strangers to reach the line and supports, and also due to the possibility to control transport facilities that terrorists will be forced to use commit act of terrorism. It also will be difficult for direct hit of STS line using piece of ordnance situated on land due to large distance from the coast and small dimensions of elements of the STS line. And what is more, the line will be equipped with systems of passive and active defence from terrorists.

The special construction of supports was designed that have high strength. For example, if 3/4 of its carrying elements are destroyed, the support will continue to uphold the STS line structure.

The STS line can be designed as two one-way lines of different directions parallel to each other and with the distance between them of 50...100 (and more) m. If one of the lines is destroyed, another one can perform functions of the two-way route by interchanging direction of movements, for example: the line will work during two hours in the direction "North - South", during next two hours - in the direction " South - North ", etc..

The results of the STS vehicle tests in the aerodynamic tube at a speed 250 km/h have manifested that lateral winds blowing with the speed within 100 km/h produce lateral capsizing forces within 100 kgf. They will not practically affect the functioning of the transport system, the more so they will not force the vehicle off the rails.

1.8.5. Ecological Safety

The STS transport system is highly safe ecologically both during erection and in operation.

The STS can be erected without any special equipment (such as platforms or construction power shovels) without using road approaches because the necessary materials and structural members will be delivered along the erected route stretches. Also, erection may obviate the need of earthwork destroying the soil level or the humus accumulated during millions of years, because the supports will be erected on posts driven into land as foundations. these features are extremely essential when the route runs over fertile or most valuable plots of land.

The STS will consume electricity for its operation as an ecologically clean source of energy. Passenger vehicles and cargo transport modules will be airtight and they can stop only at special stations, it will eliminate contamination of the environment by passengers or any other sorts of industrial waste. the containers are designed to exclude leaks (they will have no pumps, valves, seals and other joints which may leak) or losses of bulk cargoes. Any crush along the route may cause derailing of just a single module (the extreme braking path of the next module will be less than the distance between the two), also a parachute will be activated to decelerate the container so that it does not disintegrates when it drops on the land surface.

The STS needs no embankments, cuttings, tunnels , bridges or conduits. One carrying support occupies just one square meter, the anchor support occupies 10 square meters. Hence, one kilometer will require the area less than 100 square meters, i.e. 0.01 hectare, therefore the conventional land alienation will be within 10 cm. It is much less than the area occupied by a walking path.

The length of a span is not critical because both forests or individual trees along the route may remain because any support can be shifted this or that way straight during construction.

The STS route will not interfere with the migration of soil and surface water, animals, reptiles, crop growing or any other land use.

The STS will be a low-voltage line, so it will not create any electromagnetic interference and it can pass quite high (up to 100 m) over residential buildings, crop land, over game preservations and parks. Absence of sliding electrical contacts in the vehicle-contact grid couples (unlike railways) and the power of the motors exclude radio noise.

The STS requires extremely few materials for its erection, therefore it will be ecologically clean in this respect. For example, a single-track route as long as a railway can be erected from the materials of just a single rail and each third sleeper (the railway has still the second rail and 2/3 of sleepers, the contact grid, rail conduits, viaducts, etc.). Hence, the STS for its erection will not require as many blast furnaces, ore, mines (to produce steel, copper), cement and reinforced concrete plants , earth, sand and gravel quarries, the scope of deliveries by trucks and by railway cars of the materials, special approaches, etc., which would incur an additional, sometimes irreversible ecological damage.

The STS vehicle has no projecting parts, excepting narrow wheels protruding for 10 cm from the body. It needs no windshield wipers or lights (because there is no driver) which produce noise at high speeds. The wheels can be fabricated from light alloys (the load per wheel is 500...1500 kgf), therefore they can weigh within 10...20 kg. Hence, a STS train weighs hundreds of times less than a railway train, it is tens of times shorter and runs much smoother because of the track smoothness (what can be more straight than a strongly tensioned string?). Therefore, the STS train will produce hundreds of times less noise and vibration than high-speed trains.

1.9. Communication Infrastructure

The STS will be not only a high speed and ecologically clean transportation system providing comfortable, cheap and quick delivery of goods and passengers. It will also become an important demography forming factor and a powerful communication system providing transportation of information and energy, because electric power lines, electric power stations using renewable, ecologically clean sources of energy as well as wire and fiberoptic communication cam be easily combined with the STS.

1.9.1. Autonomous Power Supply.

It's a well-known fact that now the strongest negative impact on the nature is caused by electric powerful stations. That's why an autonomous power supply based on renewable sources of energy (wind and solar) should be used in the STS. Wind power is one of the cleanest sources of energy taking into account its influence on the environment. The atmosphere and water resources are not polluted by wind power generation. It doesn't exhaust limited reserves of mineral resources and doesn't change regime of water resources. Special wind-driven and solar generation units combined with the STS are also designed. Thanks to this capital construction cost is reduced. For example, capital cost for proposed wind-driven unit is estimated as 1000 US$ per 1 kilowatt while capital cost for a nuclear power plant has increased from 300 US$ per 1 kilowatt in 1960 to 4000…5000 US$/kW at present time. This is mainly caused by increased enviromental and safety requirements primordially, in the future they will be used more often than traditional sources of electrical energy.

The proposed wind-driven electrical units will work at wind speed of 2 m/sec and will have power of 5 kW at wind speed of 5 m/sec, 50 kW at 10 m/sec, 150 kW at 15 m/sec. They will be started up easily; they will not create any noise. They will not be dangerous for birds because their rotation speed will be low. Being deployed at some height, wind-driven units will allow to use soil under them for agriculture and so on. It's enough to have two 50…100 kW wind-driven electric units at every kilometer of the STS line to satisfy the needs of string transport system. The maximum quantity of wind-driven electric units corresponds to the number of supports, i.e. 20…50 units per one kilometer. Their total power will reach up to 1000…5000 kW/km. Thus, combined power of the STS wind-driven electric units will be 1…5 mln kW per 1000 km of the STS lines (in case of wind speed of 10 m/sec). The cost price of one kW of electric power elaborated by wind-driven electric units will be 0.02 US$. The expenses will be compensated within 6 years. That's why the STS in addition to its autonomous power supply can be used as a powerful electric power station to satisfy the needs in energyof those users located along the STS lines. In this case electric power will be transmitted to users by the STS lines and there will be no need to construct high voltage power lines which are rather expensive and dangerous to the environment.

It's necessary to stress that in to order create the same energy potential with the help of nuclear power plants serious investment in billions of US$ should be allocated. At the same time the problem of wind-driven electric units construction for the STS can be solved using local investments of those who live along the STS lines.

The fact that wind-driven electric units are distributed along the STS lines will be positive because together with windless zones there will be areas with strong winds which will supply the whole STS line with electric power.

1.9.2. Linear Towns

The STS lines will help to solve some demographic problems as well. Along those lines especially in mountains linear towns built in the harmony with the nature can be constructed due to ecological safety of transport infrastructure (Fig. 9). In this case there is no need to cut forests, build highways and destroy biogeocenosis in the construction zone. It will be easy to develop agriculture and ecology friendly industry. These linear towns will become basis for a rationally organised society. Construction of linear towns will require less capital investment compared to traditional building. It will be beneficial to live there because life in favourable natural and social conditions will become for a human being more important than to possess this or that thing. This will help to establish basis for future life of the society, life in unity with the Nature.

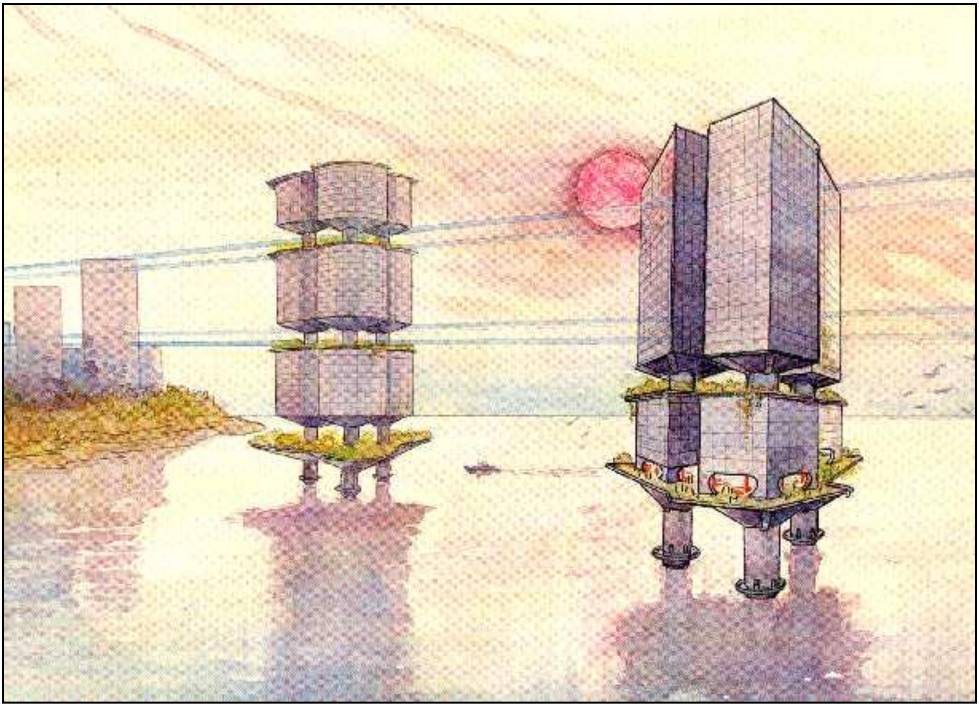

Fig. 9. Linear city on a route STS on shelf of the sea

1.10. Attractive Appearance and Comfort

The majority of the people spend their active time in a closed, limited space. Due to the ergonomics the common transport means allow to see some land surface, a portion of the road, etc.

The STS both solves the problems of comfort and its functional objective to fast deliveries of passengers to their destinations. Large windows, comfortable seats, soft silky tracks transform a common trip into the delight of enjoying the sights of nature from the birds' flight.

The appearance of slim route structures, support and stations will fit into the natural landscape without impairing the ecology or destroying even fine natural components and the historical architectural styles along the route adding islands of modern architectural shapes.

Each vehicle will be air conditioned, passengers will enjoy a broad variety of other services, multichannel music and TV, world telephone communications, special services for businessmen, passengers with children, disabled people. The STS vehicles are airtight equipped with a system of pressurized or chemical water closets to accumulate waste.

Passengers can command vehicles to stop at any intermediate station, i.e. after every 3...5 minutes.

1.11. Construction Process

The STS construction process is shown in Fig. 9.

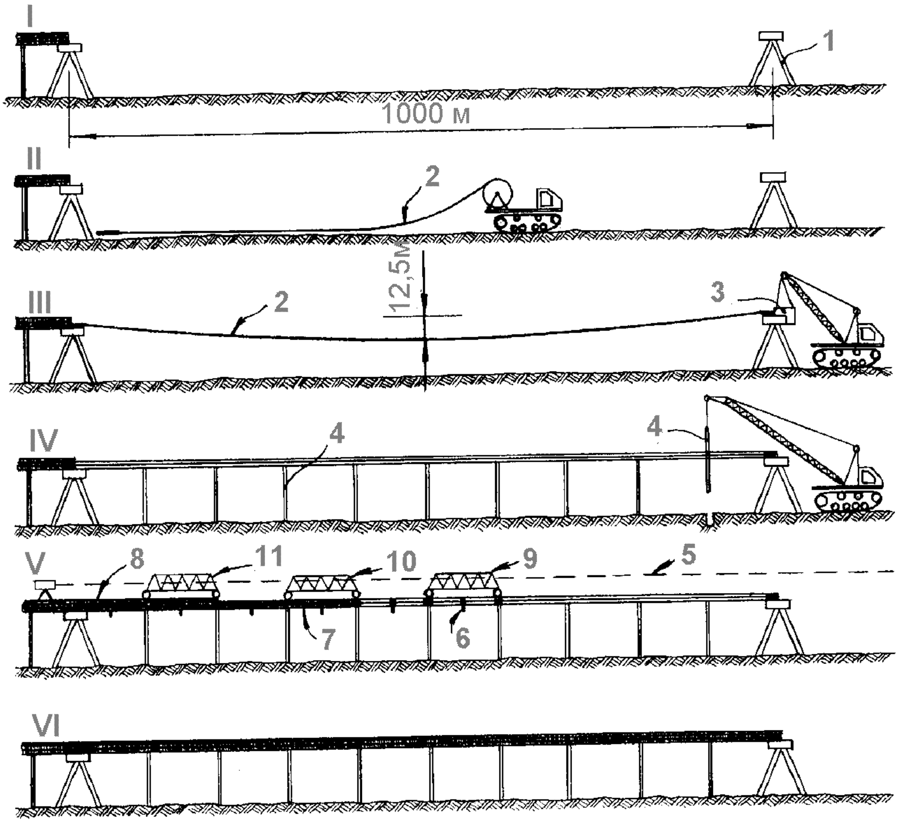

Fig. 9. STS construction process:
1 - anchored support; 2 - rope (string element); 3 - string tension mechanism; 4 - intermediate support; 5 - sight line; 6 - cross board; 7 - rail body; 8 - rail head; 9, 10, 11 - technological platforms for installation of, correspondingly: cross planks, rail body and rail head;
I - anchored support construction; II - placement of string ropes along the route; III - string stretching and anchoring; IV - installation of intermediate supports; V - erection of rail parts and route structure; VI - constructed part of the route.

The string prepared in advance is stretched to a certain tensioning (the force of tensioning or elongation in tensioning serve as a reference parameter) and its ends are secured rigidly, for example, by welding, to anchor supports. The intermediate and brake supports are erected beforehand or in the process of tensioning or after. A platform is sent along the intermediate and brake supports and the string which can travel independently and fix its position rigidly in respect to the supports. The hollow rail body is mounted with the help of the platform span after span, then it is fixed in the specified position and filled with a filler the rail head, the cross plank are erected and other necessary operations are performed to erect the route structure. All these operations are easily mechanized and automated, they can be performed during 24 hours every day in any weather to expedite construction reducing labor consumption and cost. To eliminate microroughnesses and microwaviness of working surfaces after the rail head is erected and to remove gaps between its joints the system can be polished throughout its length.

The STS can be erected with a special erection combine which tensions the string and other tensional rail members over the combine rather than over the anchor support. the combine moves along the route on its walking legs and places assembled intermediate supports with the ready rail track, once it reaches the anchor support it fastens them together securely.

1.12. Feasibility Indicators

Table 4 introduces the feasibility indicators of a double-track route 1 km long and Table 5 shows the transport system costs.

The following aggregate prices were used to evaluate the cost of structures: metallic structures depending upon their complexity and steel grade - 2,000...5,000 US$/t; aluminium structures - 5,000 US$/t; overground (above-water) reinforced concrete structures - 500 US$/m^3, underwater - 750 US$/m^3; cast concrete structures - 250 US$/m^3. Six intermediate stations have been projected each US$ 5 million. The cost of terminals (four) and service buildings was estimated 3,000 US$/m^2 of the area (general construction works plus engineering and technological equipment) and 1,500 US$/m^2 of the area of garages (workshops).

The cost of a double-route track will be on sea areas - 1.7 US$/km, on land areas - 1.1 US$/km and that of the whole route (240 km) together with its infrastructure US$ 900 millions.

Table 6 lists the major feasibility indicators, Table 7 lists the costs of transportation (the cost of transportation of one passenger and a ton of cargo). The following parameters unlisted in the Tables were used for the estimates: cost of electrical energy - 0.03 US$/kW·h; returns yielded by the transport system: 80% from the passenger traffic and 20% from the cargo traffic.

The cost of transportation of a passenger over a distance of 220 km from Nahariyya to Khan Yunis at the passenger traffic 50,000 passengers during 24 hours will amount to 4.98 US$, one ton of cargo (at 50,000 tons during 24 hours) will cost 2.20 US$. The transport system will yield a profit of 48 mln US$/year.

The profit can be increased significantly by raising the price of tickets to 10 US$ (the price of railway tickets). It will yield an additional profit of 92 mln US$ (at 50,000 passengers during 24 hours). The transport system will pay back its cost during 6.4 years. At the rate of 100,000 passengers during 24 hours the transport system will pay back its cost during 3.8 years.

If the price of ticket is 20 US$/passenger, the transport system will yield a profit of 320 mln US$/year, and the transport line will pay back its cost during 2.8 years (at 50,000 passengers during 24 hours).

The STS route can support high passenger and cargo traffic. The short travelling time (45 minutes) and low cost will make possible to make round business travels within a single day, tourist, business, shopping trips, etc.; it will broaden employment opportunities in various communities.

Table 4

Consumption of materials and cost of one km of a double-track route STS, coming along the sea shelf (the height of supports - 35 m)

Structural element	Material	Consumption of materials per km		Tentative cost, thous. US$ per km
		mass, tons	volume, m^3	
1. Rail-strings. total Including:				550
1.1 Heads	Steel	60	-	120
1.2. Body	Al sheet	10	-	50
1.3. String	Steel wire	120	-	240
1.4. Filler	Composite	-	80	40
1.5. Gluing wax	Composite	2	-	20
1.6. String protective sheath	Polymer	8	-	40
1.7. String water insulation	Polymer	4	-	20
1.8. Others		-	-	20
2. Cross plates		-	-	60
3. Intermediate supports, total Including:		-	-	380
3.1. Body of the support	Reinforced concrete	-	200	100
3.2. Cross pieces, stay guys	Steel	30	-	60
3.3. Support upper structures	Steel	20	-	50
3.4. Foundation	Reinforced concrete	-	160	120
3.5. Hydroinsulation	Mastic	-	-	30
3.6. Others		-	-	20
4. Anchored supports, total Including:		-	-	170
4.1. Support bodies	Reinforced concrete	-	140	70
4.2. Foundation	Reinforced concrete	-	40	30
4.3. Metallic structures	Steel	10	-	20
4.4. Anchor fixtures	Steel	3	-	15
4.5. Hydroinsulation	Mastic	-	-	20
4.6. Others		-	-	15
5. Earthwork		-	-	20
6. Rail power supply system		-	-	50
7. System to monitor the conditions of supports and route structure		-	-	40
8. System to monitor transport traffic		-	-	30
9. Emergency power supply system		-	-	20
10. Transport traffic control system		-	-	50
11. Emergency stop points		-	-	20
12. Surveying and mapping		-	-	50
13. Cost of land and its preparation for construction		-	-	50
14. Other tasks		-	-	60
15. Unforeseen expenses		-	-	150
TOTAL:				1700

Table 5

Cost of a double-track STS transport line
" **Nahariyya - Tel Aviv - Khan Yunis** "

No.	Description of route elements	Quantity, volume	Item cost, thous. US$	Total cost, mln US$
1	Way structure (on sea areas)	220 km	610	134.2
2	Supports (on sea areas)	220 km	550	121
3	Terminals	4 pieces	30000	120
4	Garages-workshops	4 pieces	15000	60
5	Intermediate stations	6 pieces	5000	30
6	Earthwork	220 km	20	4.4
7	Rail power supply system	220 km	40	8.8
8	System monitoring the condition of the way structure	220 km	20	4.4
9	Control system of transport traffic	220 km	20	4.4
10	Emergency power supply system	220 km	20	4.4
11	Transport traffic control system	220 km	50	11
12	Surveying	220 km	50	11
13	Cost of land and its preparation for construction	220 km	50	11
14	Research and development	-	-	25
15	Pilot single-track STS leg	20 km	1000	20
16	Other elements of the route transport infrastructure, totally	-	-	210
	Including:			
16.1	Rise in the cost of construction of long spans:			
	- the length of 500 m	20 pieces	1500	30
	- the length of 250 m	20 pieces	500	10
16.2	Areas of branching off the line (land areas)	20 km	1100	22
16.3	Special switches for branches	40 pieces	500	20
16.4	Cargo terminals	10 pieces	10000	100
16.5	Emergency stop platforms	130 pieces	100	13
16.6	In addition	-	-	15
17	Other works	-	-	50
18	Unforeseen expenses	-	-	70.4
	TOTAL:			900

Table 6

Engineering and Economic Indicators of the STS line
"**Nahariyya - Tel Aviv - Khan Yunis**"

Indicator	Magnitude
1. Transport line characteristics	
1.1. Total cost, million US$	900
1.2. Depreciation deductions, %	5
1.3. Annual operation cost and cost of maintenance and routine repairs, thous. US$	50
1.4. Term until fully repaid, years	20
1.5. Route stretch, km	240
2. Vehicle characteristics	
2.1 Cost, thous. US$:	
- passenger	30
- cargo	10
2.2. Number of seats:	
- business class	10
- first class	5
- deluxe	1
2.3. Carrying capacity, kg:	
- passenger	1000
- cargo	2000
2.4. Transport module weight (net), kg	1500
2.5. On-line utilisation factor	0.5
2.6. Reserve park of vehicles, %	20
2.7. Average annual speed, km/hour	400
2.8. Engine power. kW:	
- passenger	200
- cargo	100
2.9. Vehicle annual run, thousand km:	
- passenger	1070
- cargo	1070
2.10. Annual transportation volume by one transport module(along a 220 km leg):	
- passengers	48700
- cargo, tons	9700
2.11. Specific power losses for traction:	
- passenger, kW·h/passenger·km	0.05
- cargo, kW·hour/ton·km	0.12
2.12. Depreciation deductions, %	10
2.13. Annual operation cost, %, versus vehicle cost	10
2.14. Term until repaid, years	10

Table 7

Cost of Transportation " Nahariyya - Khan Yunis " (220 km)

Indicator	Scope of transportation (both ways)					
	passengers, thousands/day			cargo, thous. tons/day		
	20	50	100	25	50	100
1. Reduced costs:						
- US$/pass.	11.69	4.98	2.75	-	-	-
- US$/ton of cargo	-	-	-	3.88	2.20	1.66
Including:						
1.1. Costs along the transport line, total	11.18	4.47	2.24	2.79	1.11	0.57
Including:						
- depreciation deductions	4.93	1.97	0.99	1.23	0.49	0.25
- operation cost	1.32	0.53	0.26	0.33	0.13	0.07
- deductions for profit	4.93	1.97	0.99	1.23	0.49	0.25
1.2. Cost of vehicles, total	0.51	0.51	0.51	1.09	1.09	1.09
Including:						
- depreciation deductions	0.06	0.06	0.06	0.10	0.10	0.10
- operation cost	0.06	0.06	0.06	0.10	0.10	0.10
- deductions for profit	0.06	0.06	0.06	0.10	0.10	0.10
- energy cost	0.33	0.33	0.33	0.79	0.79	0.79
2. Number of vehicles for the entire route, pieces	150	375	750	750	1875	3750
3. Cost of vehicles, million US$	4.5	11.3	22.5	7.5	18.8	37.5
4. Average traffic interval between vehicles (single vehicles along one line)						
- seconds	86.4	34.6	17.3	17.3	6.9	3.5
- spacing, km	9.60	3.80	1.92	1.92	0.77	0.38

2. Comparison of the STS Performance and Economics with other High-Speed Route alternatives

2.1. General

The STS performance is better to compare with railway, automobile, air transport means and magnetic suspension trains, since the major competitors of the STS will be automobiles and traditional high-speed railways.

In all these cases a great significance should be attached to the specific consumption of electrical energy for transportation. STS transport modules have a comparatively small specific energy consumption in motion. For example, at speeds 300 km/h: 0.027 kW·pass/pass·km for passenger and 0.033 kW·h/t·km cargo traffic. High efficiency of STS motors, small energy losses in motion (good aerodynamics and low mechanical losses when a rigid wheel runs over a rigid track) make the STS transport the most economical among the existing types of high-speed transport means running with the same speeds. compared with high-speed railways in the same measures the consumption of energy is reduced 5 times, compared with magnetic suspension trains 10 times and compared with jet planes 20 times.

The STS route requires less materials, therefore it is cheaper. For example, to erect the carrying portion of the STS flat land route an insignificant amount of reinforced concrete is required - 280 m^3/km for a double-track route with supports 15 m tall. About 500 m^3/km is required if its consumption for stations and auxiliary systems is added. For comparison: consumption of reinforced concrete just for enclosures high-speed railways and routes of magnetic suspension trains is 750 m^3/km.

Since the scope of earthwork is little, so are the expenses. The STS route can run without embankments or excavations along any terrain. Earthwork will have a localized nature (drilling of holes for supports totally 100…200 m^3/km, or not earthwork is required at all in case the foundation is erected on piles. For comparison, to construct a kilometer of a modern motorway or railway requires to 10,000...50,000 m^3, 100,000 m^3 in cross country or mountainous places.

The consumption of other structural for the route and supports is as small, because cheap, available, mass-produced materials will be used.

The STS rolling stock cost can be estimated in comparison with passenger cars which are the closest analogs in dimensions and designs.

Mass produced electric motors 25...50 kW are 1.5...2 times cheaper than internal combustion engines of the same power, they are more reliable, durable, easier to operate and maintain.

The STS transport module body will cheaper than a car body of the same size because of its simpler design (absence of radiators, doors, baggage space, front hood, lights, dimensional, braking and other warning lights, windshield wipers, windows lifting mechanisms, etc.).

The STS vehicle will have a cheaper and simpler running gear and suspension (no unreliable and expensive tires, wheel turning mechanisms, simpler torque transmission to stationary wheels, no problems with tractability, etc.).

The r.p.m. and torque control systems of these two transport means cost are approximately similar and are as intricate (it is a motor r.p.m. control unit in the STS and the gear box, clutches, fuel injection system, etc, in cars).

The vehicle steering system is much simpler and cheaper than in cars, because there will be few parameters: the speed, spacing between vehicles and location (the coordinate) of a vehicle along the line. Irrespective of the computer technology progress it is still complicated to steer a car, so far only human brain can tackle the problem (the driver factor should be considered when evaluating the cost of running a car: at present hundreds of millions have to drive cars for hours daily with their own daily shortage of time). A cheap controller with its own control software will tackle the problem with the STS controlled and guided by on-line computers integrated into a net. To control a car, in addition to servomechanisms (the steering wheel and its mounting, wheel turning mechanism, gas, brake and clutch pedals, gear mechanism, etc.) a whole system is required to visualize information for steering which is unnecessary with the STS, such as windshield wipers with their actuating mechanisms and detergent delivery system (to keep the windshield clean and to ensure proper visibility), main and auxiliary lights, instrument panel, mirrors, horn, etc.

The STS vehicle will have about the same exterior and interior as a car and can be widely variable in response to individual tastes.

Also, the STS vehicle has no fuel tank (thus, no gas filling stations along the route, refineries providing gasoline and diesel fuel, oil wells are required); it does not require any system of removing and additional combustion of exhaust (for example, more strict ecological norms in many countries have recently made cars much more expensive).

Considering the above argumentation it can be predicted that mass produced STS vehicles will be 1.5...2 times cheaper than passenger cars of the same capacity, thus, it will be easier available (in future the STS advantages may lead to the creation of a wide string transport net comparable with the current network of motorways).

2.2. High-Speed Railways

High-speed railways (HSRW) designed for speeds 250...300 km/h are becoming more and more popular in the world. Their extension has gained priority in the transport, for example, the Council of Ministers of the European Community projects to invest about 200 billion ECU (until the year 2010) into their construction.

The common railway transport is not suitable for high speeds. Moreover, the earth bed subsidence should not exceed 1 mm, hence loose soil should be removed to a depth of several meters to erect such railways on the coast of Mediterranean Sea. As a rule, loose soils occupy lowlands, flooded lands, marshy land, which are a natural water system accumulating and distributing moisture among rivers. Back-filling (and compacting) in great volumes will impair the natural water flow with serious risk of dehydration of some territories, swamping of others, losses of forested lands, arable fields, etc. In fact, the high-speed route embankments will become a dike (a dam) for soil and surface water. Also, such lines will require a special enclosure (from both sides) and noise screens to fence off wild and home animals, agricultural activities, etc. In general, a high speed line will require 3.2

hectares (the data for Germany), the entire route will require 770 hectares to be vacated, e.g. the most populated and important land areas in Israel.

The STS route creates no ecological problems, it does not need embankments, tunnels, bridges or conduits. Its carrying support occupies just about 1 m^2 of land, the anchored support occupies 10 m^2. One STS km will thus require less than 100 m^2 of land or 0.01 hectare, the conventional width of the vacated land will be within 10 centimetres. It is much less than occupied by a walking path or a trail.

And what is more, the sea part of the STS line can be turned into the place of the rest and relaxation for thousands tourists from Israel and foreign countries. Anchored supports can be made as buildings for hotels, casino, restaurants, halls for sport and entertainment, that will be connected by the high-speed route to each other and to mainland. In fact, it will increase the area of Israel on 20,000...50,000 hectares. In the same way, the STS line will not take away the land from land tenures but will add it.

The span is not a critical parameter for the STS, hence forests or separate trees on land areas, where supports are to be erected, may remain, since each support can be shifted any way in process of construction.

The STS route will not inhibit migration of soil and surface water, reptiles, agricultural or any other land use.

The STS will be a low-voltage route without any electromagnetic noise, it can pass quite high (up to 100 m) over houses, fields and pastures, over wild life preservations.

Absence of sliding contacts between the vehicle and the contact grid and a modest electric power of vehicles (compared with railways) will not create radio interference in the environment.

The STS will specifically require much less materials for its erection, hence it will be the most ecologically clean. For example, a one-track STS route (on land areas) as long as a railway can be erected from the material needed for a single rail and one sleeper out of three (letting alone the second rail and two more sleepers, the copper contact wire grid and carrying supports, a thick ballast bed, earthen embankments, bridges, conduits, viaducts, etc.). Hence, the STS erection will not require so many blast furnaces, iron ore or mines (to produce steel and copper), cement factories and plants to produce reinforced cement blocks, sand and broken stone quarries, so much haulage of construction materials by trucks and railway cars, etc., all which would impose an extra, sometimes irreversible burden upon the nature.

A high-speed train is a rather strong source of noise and soil vibrations, which is not surprising with its weight of hundreds of tons, its length of hundreds of meters and locomotion consuming thousands of kilowatts. The train has a great variety of projecting pieces, connectors, joints each acting as a noise source. One wheel pair weighs about a ton, it would sure hit against microroughnesses, letting alone macroroughnesses of rail joints, for example.

The STS vehicle has no projections, excepting narrow wheel protruding for 10 centimetres. It does not even need any windshield wipers or projectors (since there is no pilot) which would also produce noise at high speeds. The wheels can be fabricated from light alloys (the load per wheel is 500...750 kgf), hence they would weigh between 10...20 kg. Hence, the STS vehicle will be hundreds of times less that the railway train, it will be dozens of times shorter, the weight of the spring-suspended portion will be hundreds of times less, the route will be much smoother (what can be more straight than a tensioned string?). Therefore, the STS vehicle will produce hundreds of times less noise or soil vibration.

The STS major advantage is its small cost. For example, experts of the European Bank of Reconstruction and Development have evaluated that a high-speed route between Saint-Petersburg and Moscow (660 km) will cost 6...8 billion US $, the cost of transportation of a single passenger will cost 123 US$ (approximately as much as along European high-speed routes). The same route between Nahariyya and Khan Yunis may be estimated to cost 2...3 billion US$, the cost of transportation over 220 km will be 56 US$. These figures exceed in 2...3 times those for the STS, though it will come in more complicated conditions (on sea areas), where at the same time, construction of the HSRW will be problematical and its cost will be increased in several times.

2.3. Analysis of Motor Transport Capabilities

The automobile transport is known to be unable to compete with railways and air transport at distances of 200...400 km and more serving as a complement of the integral transport system.

Lack of competitiveness of the automobile transport as a major means of the future passenger and cargo traffic along the Nahariyya - Khan Yunis route is apparent due to the following reasons:

- even erection of a new multilane motorway will not truly increase the speed and the comfort of the automobile transport which will be much less than that of the STS with an average speed of a passenger car being below 100...110 km/h, the buses will be still slower. It means that the time needed to reach from the downtown of Nahariyya to the downtown of Khan Yunis will be at least 2...3 hours, while an STS vehicle covers the distance within 45 minutes;
- erection of such motorway (with the account of dividing strips, multiple loops at various elevations of the "clover leaf" types, acceleration and deceleration strips, parking lots for rest, etc.) will require a strip 2.5...3 times wider than a high-speed railway for the same passenger traffic or 750...900 (!) than for a STS;
- exhaust into the atmosphere by the STS will be less than the HSRW with its 0.6 gramms per passenger-kilometer, or automobiles with their more than 10 gramms per passenger kilometer;
- the STS vehicles will be airtight with all the waste collected and dumped at depots. Experience manifests that the strip along motorways is most exposed to waste disposed by car passengers.

2.4. STS versus Aviation

The STS is advantageous when compared with the air transport due to the following considerations.

Research of transport means has allowed to discriminate clearly between the competitiveness of the air and railway transport. The so-called "transport niches" are implied defining the range of distances and speeds at which a transport means provides passengers with the utmost comfort and speed all with the least energy losses.

The analysis includes whether the absolute speed of transport means is essential for passengers or the time to reach an airport or a railway station, waiting until departure, baggage handling or the actual time of travelling. The distance is estimated between destinations as the so-called "zones of equal accessibility" located downtown. Hence, an air passenger needs 3...4 hours to travel from the downtown of Nahariyya to the downtown of Khan Yunis will require 3...4 times longer than the STS.

However, the ecological safety is the governing factor in all these comparisons. Modern aeroplanes release totally 300...400 g/passenger-kilometre or 500...600 times more harmful substances into the atmosphere than the high-speed railways or the STS, respectively. Actually, this parameter is expected to reduce 3...5 times when aviation switches over to the double-contour turbojet engines.

The major share of the exhaust accumulates exactly in the vicinity of airports, i.e. around large cities when planes fly low and the engines are boosted.

At low and medium altitudes (up to 5,000...6,000 m) the atmospheric pollution with nitrogen and carbon oxides persists for several days, after that they are trapped by moisture and produce acidic precipitation.

Aviation is the sole pollutant at higher altitudes with the harmful substances persisting in the atmosphere much longer, about one year. Even conversion to hydrogen engines fails to solve the problem. Harmless releases of the engines as water vapours close to the land surface convert into ice crystals shielding land.

Moreover, the noise effect is specifically strong around airports and electromagnetic noise around radar stations.

It is an important factor to consider that airports require land areas comparable with those for high-speed railways, yet these areas are located straight near cities implying that they are more valuable.

The major factor is the travel cost which will exceed several times that of the STS when the cost of travelling to the airport and back is added.

Thus, Nahariyya - Khan Yunis passenger future traffic lines manifest obvious advantages of the string transport routes.

2.5. Applicability of Transport Means with Magnetic Suspension

Magnetic suspension transport (MST) requires solution of sizeable scientific and engineering problems. Actually, the MST is still being experimented upon, though a number of countries have erected separate short stretches. Alternatives of implementation of the “Transrapid” System (FRG) and electrodynamic suspension and linear synchronous motors have been evaluated, they require to employ the effect of superconductivity. Israel has little experience in this domain and basically none with the electrodynamic suspension and linear synchronous motors. The MST requires 4...5 times more investment than high-speed railways and 30...50 times more than the STS. For example, the projected Transrapid route Berlin-Hamburg (Germany) 300 km long is estimated to cost 19 billion DM. Hence, a MST route " Nahariyya - Khan Yunis " may be estimated to cost 10 billion US$ (while constructing the line on land areas).

This amount is enough to build transport net of STS lines in Israel with total length about 5,000 km.

3. Stages of Implementation of the STS Project

The primary objective is to complete research and development (25 million US$) to select, optimise and adapt to the terrain relief and operation conditions of design, technological, engineering and other solutions, the know-how accumulated by the author during 18 preceding years and the specialists which he attracted to cooperate and then at the “NTL Transportlinien GmbH (Germany), since 1997 at the Research Center "Yunitran" and since 1998 at the Foundation "Yunitran" (Moscow), because it received the non-material assets accumulated during this period: patents, know-how, engineering knowledge, designing, technological and other achievements and their cost exceeds 14 billion US $, according to the estimate of the Institute of Independent Assessment of Investment and Credited Projects (Minsk). The program had been developed to develop the design of the transport line and the vehicle (with all their components) with the account of wages of designers and other staff, the cost of materials and standard pieces, equipment, expenses to attract contractors, etc. The program has been developed for the conditions in the Republic of Belarus, it can be easily adapted to the conditions of any other country with the help of correction factors.

A special designing bureau should be created together with several laboratories (to investigate motion dynamics; control, communications and safety systems; electric motors and power supply and reliability of structures) and major services (the general designer, the chief economist, the chief process engineer, the chief engineer, the chief construction engineer, the chief power engineer, the chief communications expert). This stage can be accomplished within 2...3 years providing the corresponding finances become available and 40...60 designers are recruited. Research and development can be combined with the erection of a pilot STS leg 10...20 km long.

Then the pilot route leg (20 million US$) should be erected and pilot vehicles should be fabricated (2 million US$). With sufficient finances it can be accomplished within 1...2 years. The pilot leg can be erected in any country where investors believe their investments can enjoy protection and the designer can be sure of the proper protection of the intellectual property and the copyright. The special designing bureau should also be established in this country.

The route survey can be started parallel to the erection of the pilot leg as well as the survey of other transport lines if there are clients for such projects. It will allow to become leaders of the world super high speed transport market in the XXI century.

The STS, due to its strong competitiveness, will be able to conquer the markets of high-speed communications. It will create a new economic niche by forcing out high-speed railways, trains with magnetic suspension and aviation. Because the route " Nahariyya - Khan Yunis " will lay foundation to the creation of an international net of high-speed string routes.

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