SkyWay Linear City in Abu Dhabi

Minsk 2015

Summary

The global market is waiting for the emergence of a fundamentally new transport and infrastructure technology meeting the following requirements:

- economic, resource and fuel efficiency;
- all-round safety, including environmental friendliness;
- freight and passenger applicability;
- a wide range of available distances;
- a wide range of speeds up to 500 km per hour;
- ruggedness and suitability to extreme climate conditions.

SkyWay technologies meet all of the above.

Transport and infrastructure arm of SkyWay technologies is a multitude of transportation and development and engineering solutions fitting well into the natural environment, creating a comfortable, environmentally friendly, and safe urban habitat. For simplicity this complex is hereinafter referred to as Linear City.

Linear City is a cluster-type urban settlement, where the surface of the earth is meant for pedestrians and green plants, while transport, energy and information networks are elevated above the ground on the "second level".

There is only one mode of transportation in the city — horizontal lifts connecting the high-rise towers, spaced at 500 meters and more (up to 3 km) from each other and placed along one line, or several parallel and intersecting lines.

SkyWay Linear City can be built in the desert, at waterlogged and challenging construction sites (difficult terrain), as well as offshore.

Line City concept for Abu Dhabi was developed in accordance with the emirate’s objectives set forth in the following framework documents:

- Abu Dhabi Economic Vision 2030;
- Urban Planning vision 2030;
- Plan Capital 2030;
- Plan Maritime 2030;
- Plan Al Ain 2030;
- Plan Al Gharbia 2030.

SkyWay transport and infrastructure technologies underpinning the Linear City meet all the key requirements of the Estidama national development system.

The basic principle of the construction of each infrastructure cluster is that it is a pedestrian quarter, in which comfortable low-rise buildings are put between the multi-functional high-rise buildings connected by a horizontal lift, with widespread landscaping of urban areas and use of renewable energy sources.

The horizontal lifts are the key element of the system — they are the transport arteries connecting neighboring high-rise buildings, settlements, residential, shopping, entertainment and other clusters, allowing for comfortable transit within a few minutes. An important advantage is that the cost of the public transport can be included, as it is done with conventional elevators in the buildings, into the square meter price of the Linear City premises, while keeping the average market price for new residential premises.

In fact, when implementing the SkyWay Linear City development project, the Abu Dhabi Department of Transport is basically pursuing the state policy on modernization of public transport while not spending the budget.

At the same time substantial savings are offered due to:

1) reduced cost of construction of paved roads — up to 90%;
2) reduced cost of maintenance of paved roads — up to 90%;
3) reduced harmful emissions into the ambient air — up to 90%;
4) reduced energy consumption by transport — up to 90%;
5) reduced municipal transport costs — up to 90%;
6) reduced costs of irrigation of green areas due to recreation of fertile soil — up to 90%;
7) reduced cost of urban landscaping — up to 100%.

The benefits offered by SkyWay transport and infrastructure complex:

1. **Low cost of construction and transport services**

   Construction of the SkyWay transport complex is 2—3 times cheaper than a railway (streetcar) and 3—5 times than a motor roads system, 10—15 times cheaper than monorail and 15—20 times cheaper than magnetic suspension trains, while offering 3—5-fold lower cost of transportation.

2. **Low power consumption**

   Power consumption is 5—7 times lower than that of the existing transport systems that use steel wheels or magnetic cushion, 15—20 times lower in comparison with transport running on pneumatic tires (motor vehicles) or hovering vehicles (aviation, WIG, helicopters).

3. **Minimal footprint**

   The land plot required for the transport and infrastructure complex is roughly 100 times smaller in comparison with road and rail (tram) systems, and when using the suspension system for connecting urban high-rise buildings there is no need for expensive land allocation for transport at all.

4. **Full automation**

   Automation of the transport and infrastructure complex and optimal transport logistics — in the Linear City the average home-to-work commute will not take more than 15—20 minutes at distances up to 15 kilometers.

5. **Unprecedented safety**

   High level of transport and environment safety and anti-terrorist security, as there are no intersections, pedestrian crossings, oncoming traffic with the risk of head-on collisions, while the high-rise string-rail track structure has a tenfold safety factor and is not accessible for vandals, and the rolling stock is equipped with a derailing-prevention system.

6. **High-speed performance**

   Public transport — up to 120—150 km/h; intercity high-speed transport — up to 450—500 km/h.

7. **Minimal operating costs**

   Operating costs are 5—7 times lower than in case of the motor road system, and 2—3 times lower than those of the rail (streetcar) transport.

8. **Using renewable energy**

   The SkyWay transport complex uses electric motors for efficient and low-cost "steel wheel — steel rail" coupling (including use of a unique motor-

wheel) and can cover 100% of its energy needs with renewable energy — solar and wind.

9. **Restoring the fertile soil**

   It is possible to restore fertile soil and natural ecosystems — fauna and flora (SkyWay-Agro technology) — in any habitat, including in the desert.

10. **No harmful impact on people and the environment**

    Harmful impact — exhaust gases, noise, vibration, electromagnetic and other radiation are 15—20 times lower than those of the road systems and 2—3 times lower than in case of rail (streetcar) and monorail tracks.

11. **Cost- and time-efficiency**

    Cost and time saving for passengers and shippers: time of city transit (delivery of goods) is reduced by up to 1—1.5 hours per day, translated into up to 20—30 USD per day per passenger or ton of cargo.

12. **Fast payback**

    SkyWay transport and infrastructure complex has unprecedented payback period: 2 to 3 years.

To illustrate the layout of SkyWay Linear City we have chosen the difficult and hard-to-get-to Al Hudayriat Island to the south of Abu Dhabi (the state reserve lands).

Bird's eye view of Al Hudayriat Island (Google Earth), 2015.

The following are the options for placement of SkyWay Linear City on the Al Hudayriat Island showcasing various concepts of desert and inaccessible areas reclamation in the Emirate of Abu Dhabi:

- Option 1: National Park on the Al Hudayriat Island with SkyWay Linear Cities around the perimeter of the island and off the shore.
- Option 2. Eco-city on the Al Hudayriat Island with the jungle and the SkyWay linear city off the shore.
- Option 3: Cluster-type Ecocity on the Al Hudayriat Island with Skyway Linear City off the shore.
- Option 4: Cluster-type Ecocity on the Al Hudayriat Island with Skyway Linear City off the shore.

Every proposed development project is revolutionary in terms of its infrastructure performance and can be accepted by the customer for implementation.

Option 1: National Park on the Al Hudayriat Island with SkyWay Linear Cities around the perimeter of the island and off the shore (2019)

Option 2. Ecocity on the Al Hudayriat Island with the jungle and the SkyWay linear city off the shore (2019)

Option 3: Cluster-type Ecocity on the Al Hudayriat Island with Skyway Linear City off the shore (2019)

Option 4: Cluster-type Ecocity on the Al Hudayriat Island with jungle and Skyway Linear City off the shore (2019)

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1. Introduction

For almost 40 years of the scholar, engineer, and inventor Anatoli Yunitski has been developing a fundamentally new approach to global passengers and freight transport — SkyWay transport infrastructure complex.

He has created the SkyWay group of companies for designing and construction of communications and infrastructure systems that will allow humanity to reach the only viable stage of development in the conditions of intensive global population growth and depletion of resources — that would be to reduce energy, resource and transport costs when moving passengers and cargo.

A network of string-rail roads will engrid planet in the 21st century and elevate the transport above the ground. In its wake it will leave the planet's surface, covered with flourishing gardens, forests and fields, to the people, giving us and our children the opportunity to walk without fear of being caught dead under the wheels of cars and trains.

In the coming decades string transport may take up about 50 percent of the global transport market, making SkyWay group of companies and its partners the leaders among the largest transportation providers.

Distinction of SkyWay String Transport System (SkyWay technology) is attributable to the range of its design, technological and operational features.

The track base is the tension-prestressed uncut string rail (light transport system. See Fig. 1) or the tension-prestressed load-bearing string truss (heavy and multifunctional transport system).

Track structure for heavy-duty and/or high-speed strings transport system uses tension-prestressed double-row string truss spans with extreme vertical and horizontal rigidity.

String-rail track structure is a perfectly smooth medium for the movement of the steel wheel, as it has no technological and expansion joints along its entire run (the rail head is welded in one section). String rail is characterized by high strength, hardness, smoothness, manufacturability and assemblability, low resource intensity, wide operating temperature range: from +70 °C (heating in the sun) to –70 °C. The string used is a high strength prestressed steel twisted or untwisted lay made of

3—5 mm high-strength steel wires that come standard in many countries. The length of such commercially available wire is up to 10 km.

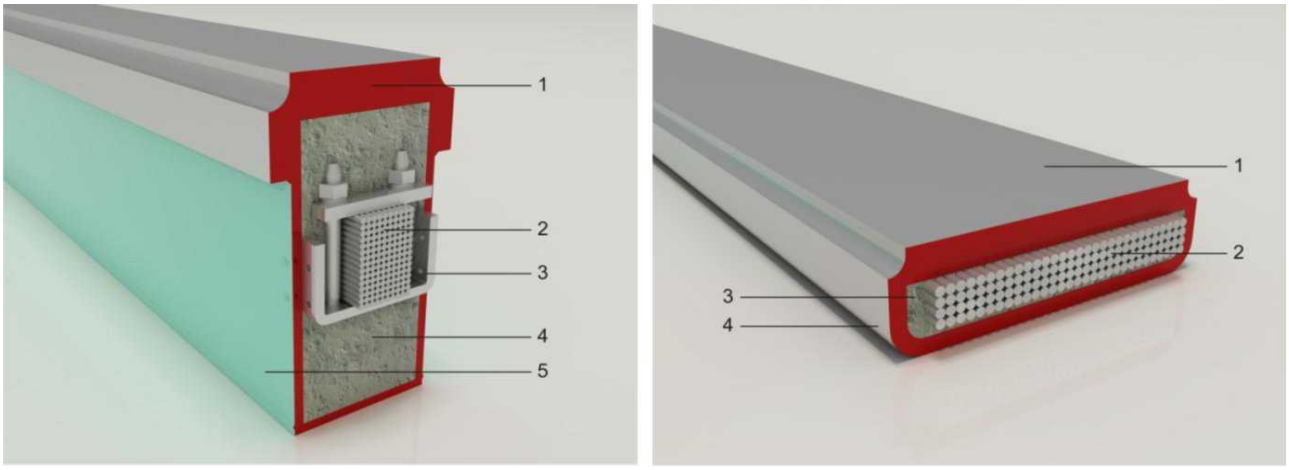

Fig. 1. Structure of the SkyWay string rail: gantry-mounted (left-hand) and suspended (right-hand)

1 — railhead; 2 — string (steel wires assembly); 3 — sting to rail body mount; 4 — filler (special concrete); 5 — rail body

1 — railhead; 2 — string (steel wires assembly); 3 — filler (special composite material); 4 — rail body

One track string-rail system uses one string rail (monorail system) in suspended format, and two string rails (birail system) when mounted.

String rails are rigidly attached to anchor towers placed every 2—3 km or more, and leaning on intermediate mounts, creating long spans of 40—50 m and more. The optimum height of the towers is 6—8 m. At specific sections of the route, if necessary, the height of the towers can be reduced to 1 m or less, and, conversely, increased to 10—20 m or more. Towers are shown in Fig. 2.

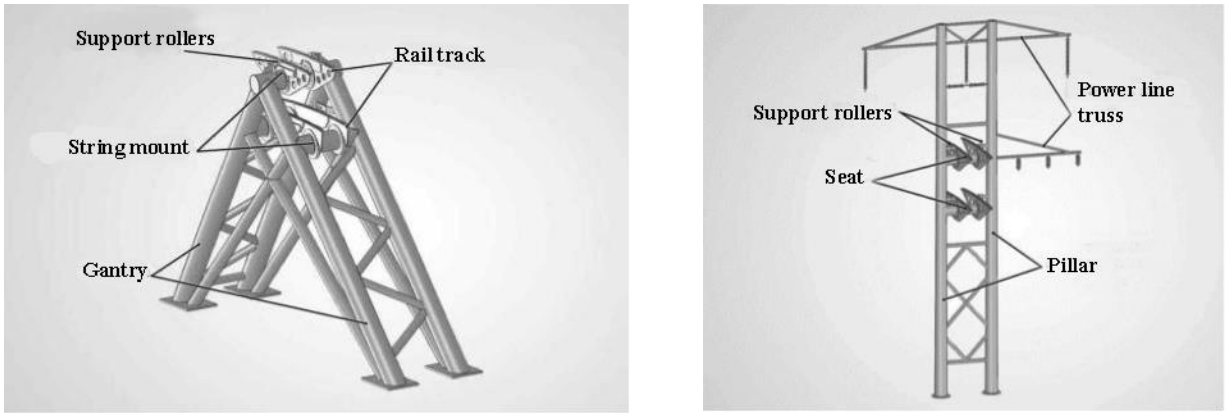

Fig. 2. Anchor tower (left) and intermediary mounts for suspended freight systems, combined with high-voltage and low-voltage power lines

The towers may be made of reinforced concrete (precast or monolithic), welded steel structures, composite materials, or high strength aluminum alloys. Their foundations, depending on the soil, can be pile (precast, screwed, bored and cast-in-place pile or augercast) or slabby-monolithic or modular.

The tower and the continuous string-rail form a rigid frame structure; therefore the bearing capacity of mounts and towers is 8 times higher than, for example, that of conventional monorail (the cost of towers will, respectively, be lower).

The wheels of the rolling stock are made of high strength steel or high-strength light alloy and attached to the vehicle body through independent "car" suspension. Two ribs or side anti-derailing roller (instead of the flange) on each wheel preclude derailing of the rolling stock off the string-rail track (see. Fig. 3).

The rolling resistance factor for the steel wheels on steel rail is 0.001—0.0015, that is 1.5—2 times lower than that of railway taper-face wheel. Mileage (resource) is up to 1 million km or more. Steel wheels are cheaper and lighter than pneumatic tires of the car and 15—20 times more durable.

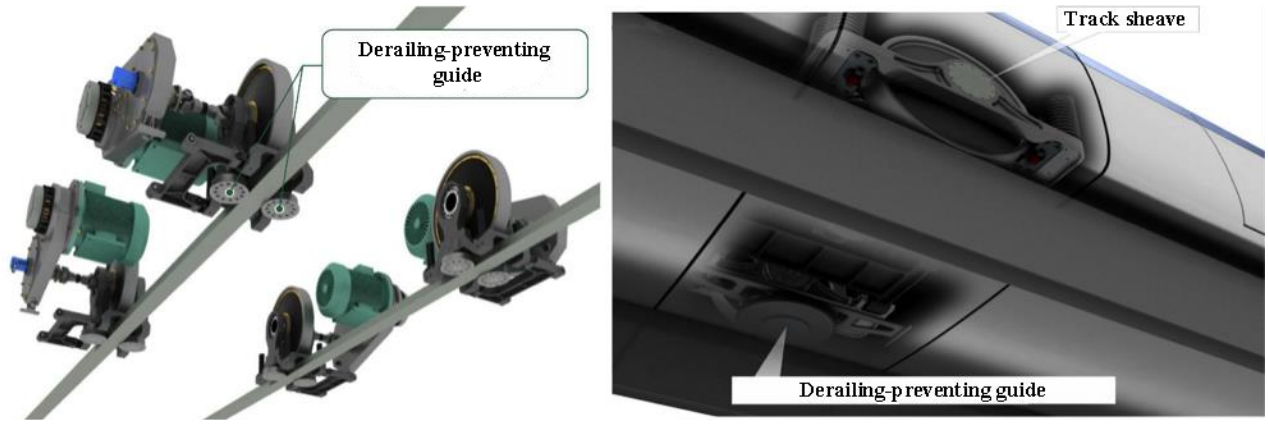

Fig. 3. Side derailing-prevention rollers variations
(left — for suspended system, with railcar suspended on the rail track,
right — for the mounted system, with the railcar sitting on the rail track)

The vehicle used (passenger unibuses, freight unicars) is a variation of the car running on steel wheels. Like a traditional car, rolling stock of the SkyWay transport system may employ different types of drive - internal combustion engines, including turboprops, electric motors, and finally, hybrid drive system (see. fig. 4).

Fig. 4. Passenger SkyWay railcars— unibuses
(left – high-speed intercity running at up to 500 km/h,
right — city transit, up to 150 km/h)

Key features of urban passenger technology:

1. Speed — 150 km / h.
2. The rolling stock capacity:
   - passengers — up to 100 people;
   - cargo — up to 10 tons.
3. Declivity — up to 15%, in case of special design — up to 30%.
4. Transportation distance — up to 300 km.
5. High-speed urban traffic volume:
   - passengers at rush hour — up to 30 thousand people per one transport leg;
   - cargo — up to 1 thousand tons per day per one transport leg.
6. The cost of urban trestle highway, net of the rolling stock cost, passenger stations and infrastructure — from 1.5 million USD/km.
7. Cost of urban rapid transit — 2 times lower than the cost of transportation by underground, 3 times lower than by tram, 5 times lower than by monorail.

It should be noted that the proposed SkyWay technology is not limited solely to string-rail transport, but also includes integrated infrastructure solutions.

2. SkyWay Infrastructure technology

SkyWay infrastructure technology includes:

- Linear city (see. Fig. 5 and 6);
- Overhead power transmission system and communication lines, combined with the SkyWay “second level” transport systems (see. Fig. 7);
- Overhead pipelines for bulk, liquid and gaseous cargo (see. Fig. 8);
- Strings roads, railtracks and pedestrian bridges (see. Fig. 9 and 10);
- Runways (see. Fig. 11);
- Sea freight terminals and ports (see. Fig. 12 and 13);
- Overland freight terminals (see. Fig. 14);
- Technologies for natural fertile soils reclamation (see. Fig. 15)

2.1. Linear city

Fig. 5. SkyWay Linear city

Fig. 6. Residential cluster in SkyWay Linear City
(due to its size the SkyWay tracks are virtually invisible)

2.2. Overhead power transmission system and communication lines, combined with the SkyWay “second level” transport systems

Fig. 7. Power and communication lines combined with container tracks

2.3. Overhead pipelines for bulk, liquid and gaseous cargo

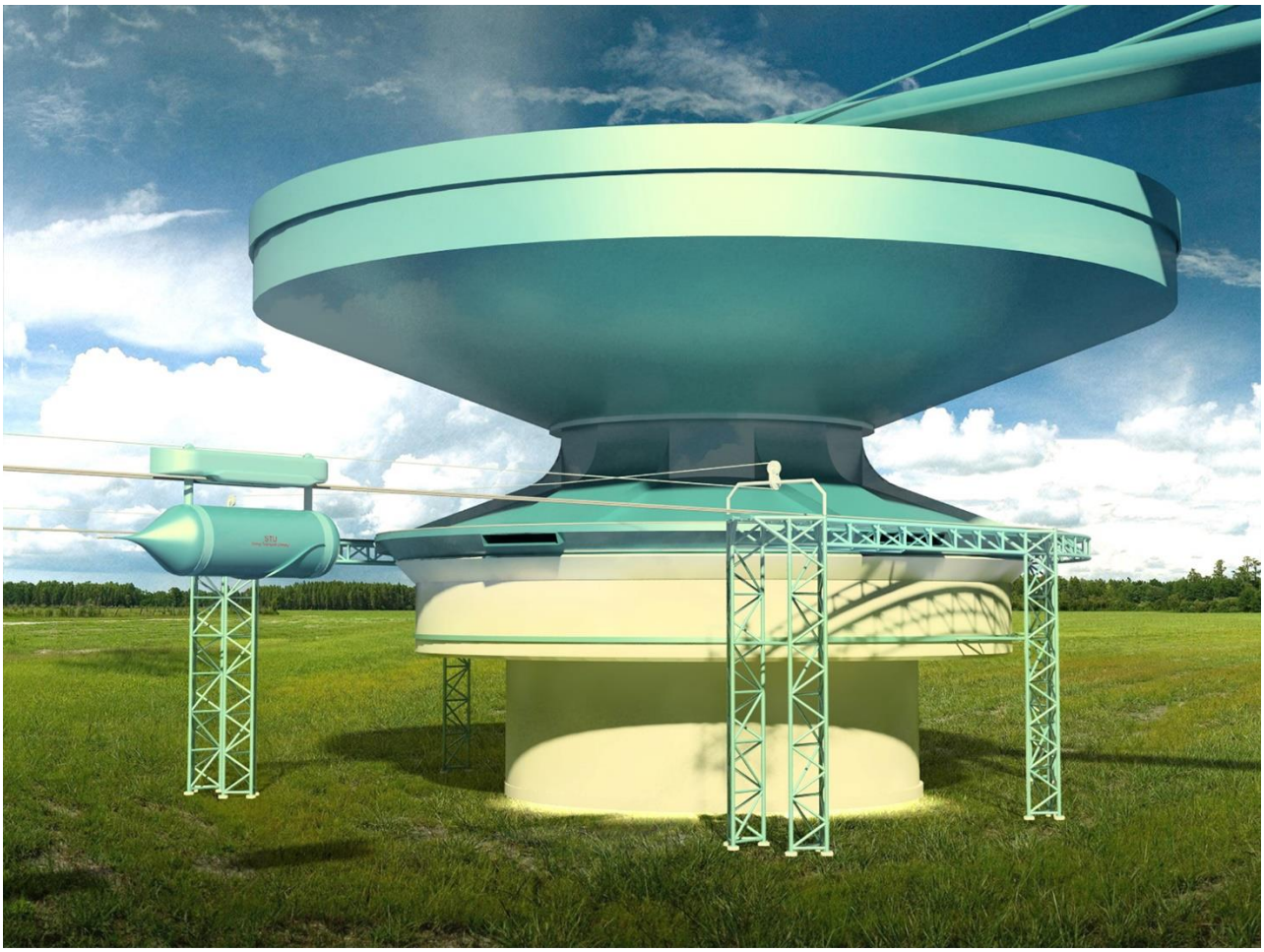

Fig. 8. Oil terminal

2.4. Strings roads, rail tracks and pedestrian bridges

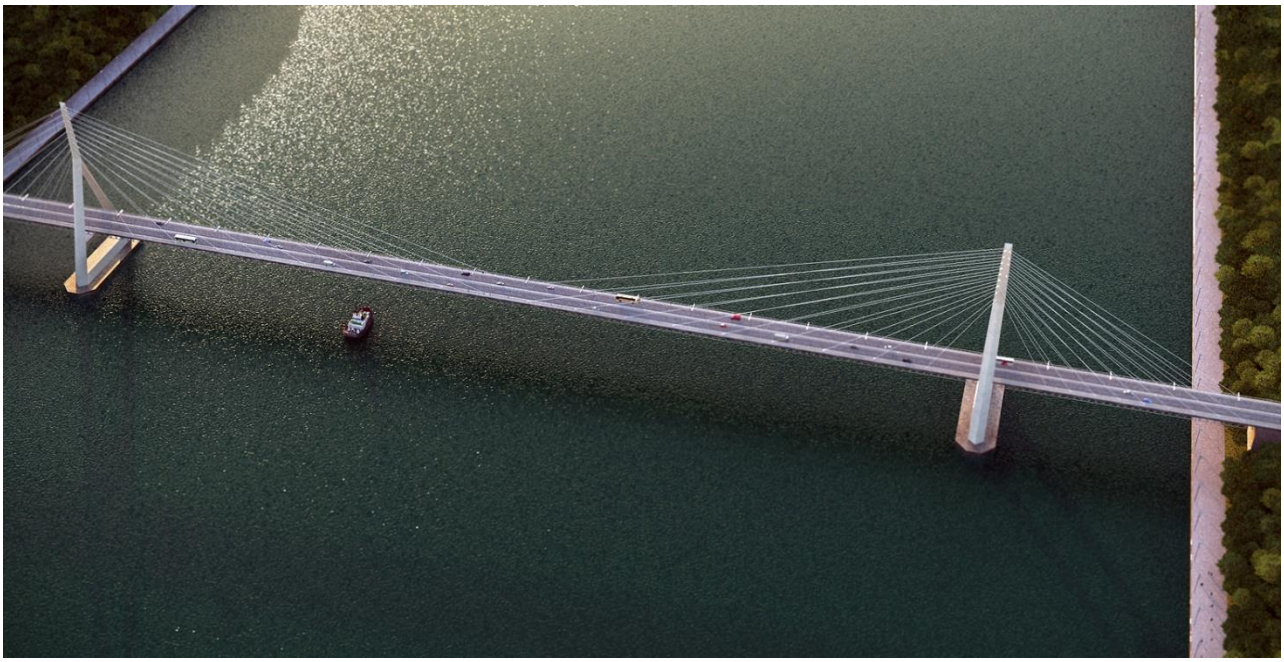

Fig. 9. General view of the road cable bridge using string technology

Fig. 10. Side view of the longitudinal sting trusses supporting the cable bridge road

2.5. Runways

Fig. 11. String runway built without compensation joints (longitudinal and lateral)

2.6. Sea cargo terminals and ports

Fig. 12. SkyWay sea port

Fig. 13. Sea port for bulk loading (coal, ore, gravel, etc.)

2.7. Overland cargo terminals

Fig. 14. Cargo bulking terminal at a mineral deposit

2.8. Technology for natural fertile soil restoration

Technology for restoring the natural fertile soil in desert regions and farming technologies for growing organic food without the use of fertilizers and GMO.

Fig. 15. Oasis in a desert with the restored fertile soil

3. Our offer

The innovative Linear City approach to urban planning offers a number of advantages over the traditional city building and effectively addresses the key challenges the Abu Dhabi Department of Transport is currently facing:

- reducing the cost of construction of roads;
- reducing the cost of maintenance of roads;
- reducing harmful emissions into ambient air;
- reducing the time needed for urban commute;
- elimination of public transport accidents and traffic accident fatalities;
- elimination of traffic congestion in the city;
- restoration of the environment in the city and additional landscaping.

Today we are offering the Abu Dhabi Department of Transport to set up a SkyWay technology-based joint company to implement the new concept of urban development, that best meet the needs of the region.

The developer company set up in collaboration with corresponding government agency will generate the revenue as follows (income estimated for one 500×500 meters Linear City block):

1) **sale of residential and office premises** (the most sought-after properties):
   - sale of private villas (living area of around 50 000 m^2) will generate about **140 million USD of income**;
   - sale of residential and commercial premises in a high-rise tower station (40 000 m^2) will bring about **84 million USD of income** (in four tower stations — **336 million USD**);

2) **transit of passengers** (in case of implementing the maximum capacity of the transport system — one million passengers per day) more than **73 million USD per year** per each kilometer of SkyWay track (**292 million USD per year** from one Linear City block, estimated at the 0,2 USD/pass.×km rate of return). At the same time public transportation will be free for the Linear City residents, because: a) symbolic fare could be included in the monthly utility bills along with other services (use of elevators, cleaning, waste disposal, etc.); b) the fare will be paid by visitors (non-residents of the Linear City), while the cost of transportation for the city visitors, even with this

additional burden, will be several times cheaper than conventional public transport in, for example, neighboring Dubai.

The total approximate revenue from implementation of the development projects for construction of one SkyWay Linear City block (500×500 meters in size with the construction period of 3 years) will be about **476 million USD**, and the income from passenger transportation can over time (when the Liner City is fully developed) amount to **292 million USD**. Construction of the next SkyWay Linear City block will be more cost-effective, given the availability the existing infrastructure.

Resources needed for the project:

1) Technological resources (SkyWay transport and infrastructure technologies, license to use the intellectual property, patents and know-how).
2) Administrative resource (participation of Abu Dhabi Department of Transport and other relevant government agencies).
3) Financial resources (raising public and private investments).

3.1. Project budget

The main components of the project budget:

1) Cost of preliminary design of Linear City transport infrastructure — 5 million USD.
2) Cost of architectural and construction design of the residential cluster with four towers — 10 million USD.
3) Cost of creating the 30 cm thick soil layer at 1×1 km (100 ha) land plot — 29.5 million USD (or 29.5 USD/m^2, net of the irrigation system).
4) Cost of construction of one tower station (including two passenger stations) — 1000 USD/m^2 × 40 000 m^2 = 40 million USD.
5) Cost of construction of one villa (including soil layer) — 1500 USD/m^2 × 200 m^2 = 300 000 USD.
6) Cost of 1 m^2 of turnkey finishing (and furnishing) — around 1 000 USD/m^2.
7) Additional cost of the station infrastructure integrated into the tower (spaced over 2 floors) — 1000 USD/m^2 × 500 m^2 = 500 000 USD.
8) Cost of 1 km of high-rise SkyWay double-rail track — from 1.5 million USD (the price depends on the volume of order).
9) Cost of 1 cargo-passenger train (composed of 3 unibuses with the total capacity of up to 45 passengers) — 500 000 USD (the price depends on the volume of the order).
10) Cost of automated traffic and safety control, power and communications — from 200 000 USD/km of double-rail track (the cost depends on the volume of the order).

3.2. The cost of building one SkyWay Linear City cluster block

Preliminary cost of the project to build one SkyWay Linear City cluster block (500×500 meters land plot):

1) Preliminary design: 1 million USD.
2) Architecture and construction design: 10 million USD.
3) Construction: 7.38 million USD (soil) + 160 million USD (two towers, turnkey) + 125 million USD (250 turnkey villas, with furniture and gardens) + 2 million USD (four high-rise stations) + 1.5 million USD (1000 meters of string-rail track) + 1 million USD (two three-section unibuses) + 200 thousand USD (automation of 1000 m track) = 308,080,000 USD.
4) Marketing (5% of the cost): 15,404,000 USD
5) Force majeure: 323 484 000 + 5% = 339,658,200 USD

Total: 339,658,200 USD (excluding roads and conventional communications).

The cost of the SkyWay transport system, its infrastructure, and rolling stock is so low, that it can be included in the price of Linear City real estate. This will increase the cost of real estate by only 30—40 USD/m^2 (depending on the development scheme), thus the transport and communication system of the eco-city can be built solely at the expense of the developer, without using the city budget.

The same applies to the restoration of natural fertile soil (the way it was in the Arabian Peninsula millions of years ago) — its cost may be included in the cost of the land — about 20 USD/m^2, or 2000 USD per one hundred m^2 (given that in cases of lawns it would suffice to have a 10 cm soil layer instead of 30 cm gardens and green areas).

Project implementation period — 3 years.

4. The benefits offered by SkyWay Linear City project to the emirate of Abu Dhabi

1. Economic, energy and logistics benefits

Issue: The need to reduce the cost of construction and operation of urban roads.

Solution: Low capital and operating costs of the SkyWay transport and infrastructure system.

The municipal cost of construction of high-speed urban transit lines is significantly reduced, as the proposed transport infrastructure is included in the price per square meter of housing in the SkyWay Linear City and is an integral part of the new approach to urban development — the elevated transportation system is paid for by the real estate buyers.

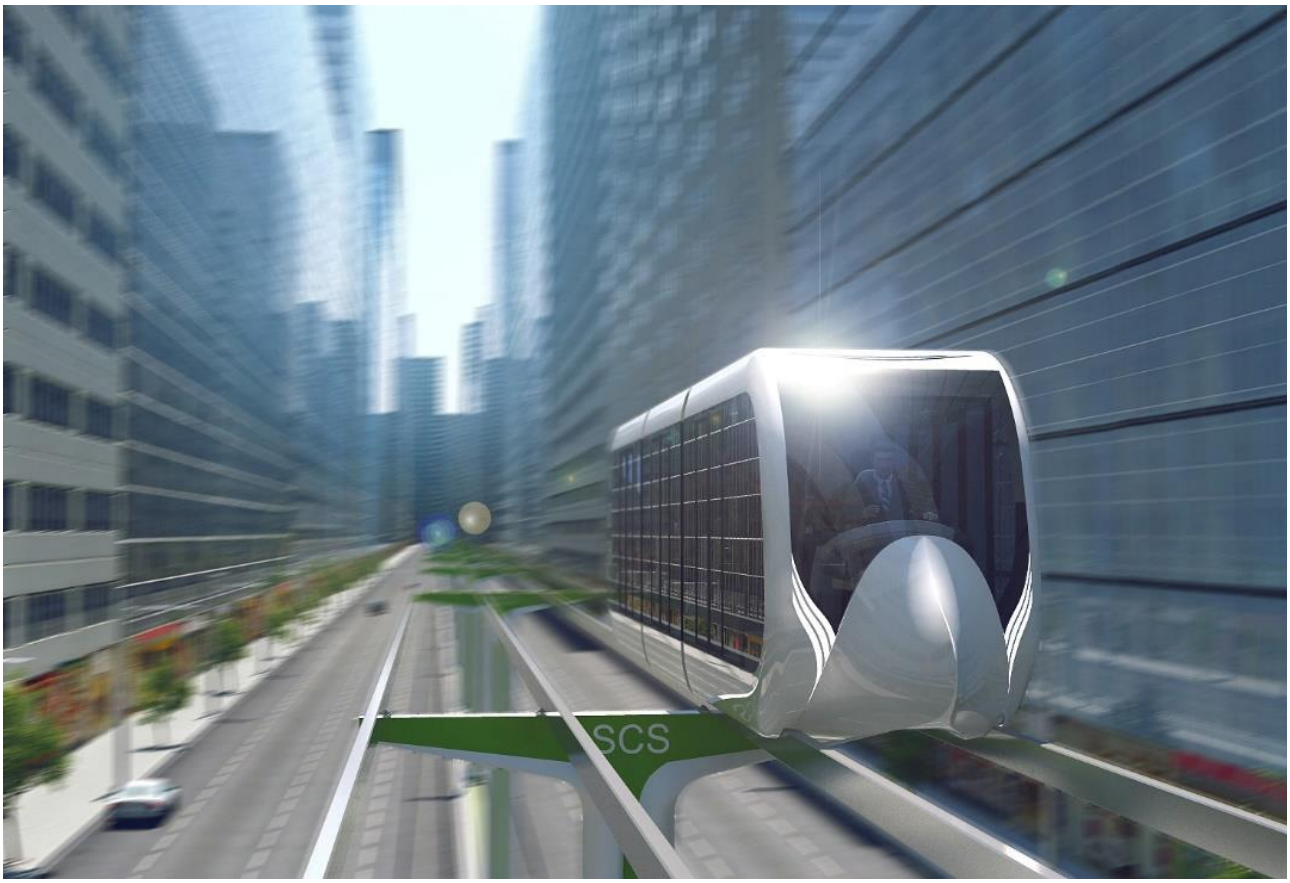

Fig. 16. Mounted SkyWay transport in a typical downtown setting

The capacity of overhead SkyWay urban transport system is about 1 million passengers per day and can be used both for carrying passengers and cargo. Wherein:

- the cost of travel for 1 km — 0.05 USD/pass.;
- commercial fare per 1 km — 0.25 USD/pass.;
- transportation profitability: 0.25—0.05 USD/pass. per 1 km × 1 million passengers per day × 5 km (average travel distance) = 1 million USD per day or 365 million USD per year).

The distance between adjacent SkyWay stations is 500—800 meters, which provides pedestrian access to the station from anywhere in the residential neighborhood (maximum distance of not more than 400 meters, on average — less than 200 meters).

Public roads of the Linear City are meant only for special municipal transport with internal combustion engines (cleaning, fire, ambulance, police, personak vehicles of the residents, etc.).

Maximum allowed speed of the SkyWay overhead passenger transport system in the SkyWay Linear City — up to 120 km/h, and between cities — up to 450 km/h.

Upon request, the SkyWay transport system of linear city can be provided in one of two options:

1) Trestle with straight string-rail track

Fig. 17. String-rail transport with rigid rail track

Energy consumption by the trestle with the straight track with the distance of 750 meters between the stations and the transport module — unibus — weighing 10 tons (45 passengers — mini-train with three carriages for 15 passengers each):

- travel time between stations — 54.8 s;
- maximum power consumption (during acceleration) — 302.6 kW;
- acceleration/deceleration — 1,0 m/s^2;
- maximum speed — 27.4 m/s (98.6 km/h);
- average speed — 13.7 m/s (49.3 km/h);
- energy costs for the 750 m run — 1.1 kW × h;

2) Overpass with slacking string-rail track

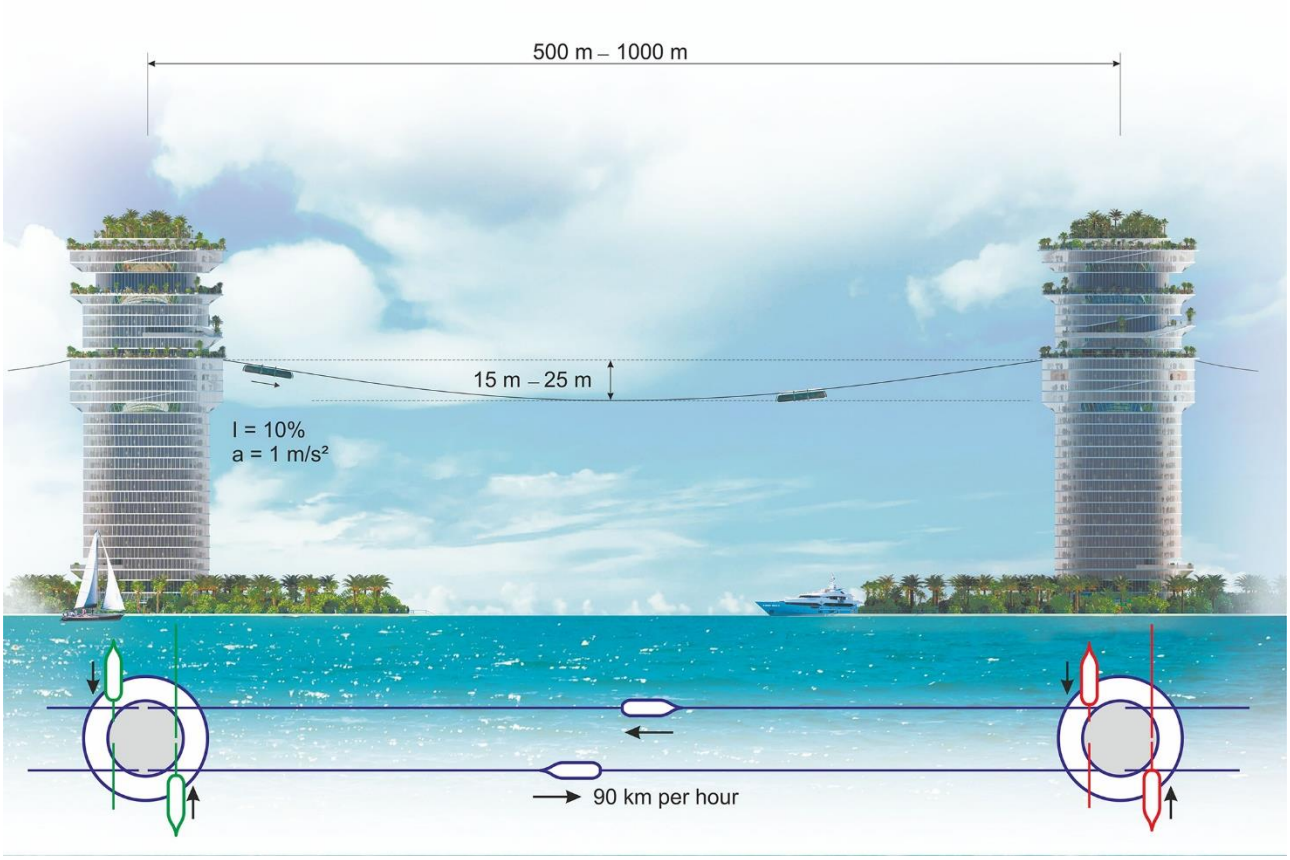

Fig. 18. Section of the city line overpass with slacking string-rail track between adjacent stations in high-rise towers

Energy consumption in case of the trestle with the slacking track with the distance of 750 meters between the stations and the transport module — unibus — weighing 10 tons (45 passengers — mini-train with three carriages for 15 passengers each):

- travel time between stations — 53.7s;
- maximum power consumption (during acceleration) — 13.6 kW;

- acceleration/deceleration — 1.12 m/s^2;
- maximum speed (mid-way) — 22.45 m/s (80.8 km/h);
- average speed — 13.97 m/s (50.3 km/h);
- energy costs for the 750 m run — 0,06 kW × h.

Conclusion: In terms of energy consumption the slacking rack (any, not just SkyWay) is about 18 times more efficient than the same stretch of straight track (1.1 kW × h/0.06 kW × h = 18.3). In both cases steel wheel on steel rail coupling is used. In case of the conventional road transport using "pneumatic wheel on asphalt" traction, energy efficiency is 4—5 times further lower, and in comparison with SkyWay slacking track — 70—90 times lower (!).

This is due to the fact that during the descent the unibus needs no drive from the engine — it accelerated by gravity. At the ascension it does not need brakes — gravity ensures deceleration. In this case initial potential energy of the unibus at the departure is converted into kinetic energy during the motion and then — into the potential energy at the destination station. That is, there is energy recovery taking place with no recuperator, since it is preconditioned by laws of physics, not created by mechanisms. Efficiency of such recovery is 100%.

The engine in this transport system is only required to compensate for losses — aerodynamic ones and the rolling resistance of steel wheels on steel rail. Since unibus offers way better performance than any known means of transport (car, electric car, tram, high-speed train, airplane, etc.), these energy losses are so low that a 45-passenger unibus, capable of doing 80 km/h, needs the engine as powerful as for a single-seater moped (13.6 kW, and this power is needed only for one-third of the time, during acceleration, so averaged power consumption during the run is 4.5 kW, or 0.1 kW per passenger, meaning that it basically need less power than, for instance, produced by a cyclist riding a bicycle).

> For clarity, we present calculations savings of the urban transport system in fuel terms.
>
> During 1 hour of running on the slacking track with 15-second stops at each station a unibus can save 53.5 kWh of electricity. In case of automatic transport system with round the clock operation (24 hours) savings amount to 1284 kWh per one unibus per day, which corresponds to 360 liters of fuel (diesel). **One unibus will save 131 thousand liters (105 tons) of fuel per year.**

Thus, in one year the transport network operating, for example, one thousand of transport modules will save 468 660 gigawatt-hours (GWh) of electricity, which corresponds to 105 thousand tons of diesel fuel (52 fuel tanker trains with forty 50-ton tanks).

The transport system servicing one Linear City block (with 2 stations) needs constant circulation (within the block) of at least two unibuses.

During one day of operation of the system 720 liters of diesel fuel will be saved. In one year the savings will amount to 262 800 liters, or 210 tons. This fuel will not be burned neither in internal combustion engines of cars or in the furnace of power plants to produce electricity.

Logistic performance of SkyWay transport system

Transport system capacity — up to 30 thousand passengers per hour in both directions of the leg.

The capacity of about 720 000 passengers per day can be achieved even on one leg of the Linear City transport system.

SkyWay transport system for the Linear City can be easily scaled to the required passenger traffic.

Linear city logic suggests walking distance to passenger stations of the overhead transport system.

The grid pattern of the transport network ensures accessibility of the stations at a distance of not more than 400 meters from any place in the Linear City. Thus, passengers spend no more than 5—7 minutes on their way to the station, including the elevator ride. The travel time between the adjacent stations will range from 54 to 74 seconds (depending on the distance, which may vary from 500 m to 1000 m).

The distance that the passenger needs to go, according the Linear City logic, is about 5 km. Thus, if a Linear City has, for example, 50 kilometers of overhead tracks, this will make 10 lines with a total capacity of 7.2 million passengers per day.

If the passenger's departure and destination points are both in high-rise buildings and no connection is required en route, travel will take up to 15 minutes (including the average waiting time for the transport module). If a connection is required — the total travel time will be up to 17 minutes.

On the other hand, if the passenger’s departure and destination points are not in high-rise buildings, part of the route will be covered walking through special pedestrian zones. The average walking distance in this case (totally at the point of departure and destination) will be up to 500 meters, which can be covered in up to 7 minutes.

Thus, in the worst case scenario (the destination of the passenger is not in the high-rise building, the passenger goes the full distance and there is a connection en route) 5 km can be covered by public transport in "door to door" format in up to 24-minute time.

The service life of the SkyWay Linear transport system (overpass) is up to 100 years. At the same time the operating costs are minimal — no annual repairs and maintenance of overpasses, the system is fully automated, requiring only a minimum number of staff.

2. Environmental benefit

Issue: The need to reduce harmful emissions into the atmosphere.

Solution: Zero carbon emissions when using SkyWay technology.

Pedestrian city will eliminate the problem of gas pollution of cities, eliminating the need for residents to use vehicles with internal combustion engines for urban travel.

Fig. 19. Bird's-eye view of the SkyWay Linear City built in the desert with the restored 30 cm thick layer of fertile soil

Linear city logic suggests walking distance to the nearest SkyWay transport station of no more than 250—400 meters (there are 4 transport stations servicing different lines within walking distance).

In hot climate and under the bright sun all the streets of each Linear City block (cluster) are connected to the nearby transport stations with pedestrian green "tunnels" made of climbing and flowering plants, vines and shrubs offering comfortable walking to the urban transport station.

Fig. 20. Sidewalk sheltered from burning sun

Any resident of the cluster block can use individual environmentally friendly vehicles (electric car/Segway/bicycle) to move across the Linear City (parking spaces for private vehicles provided next to the station). At the same time in each cluster 210 tons of fuel will be saved within one year in comparison with conventional transportation, with all the ensuing environmental benefits (see above Benefit 1).

Furthermore, SkyWay transport system unibuses are a variation of the high-efficiency electric cars, just running on steel wheels. They have a 70—90 times higher energy efficiency, than for instance, Tesla cars — 4—5 times higher efficiency due to replacement of pneumatic tires with steel wheels and 18 times higher efficiency due to slacking track between the adjacent city transport system towers.

3. Biospheric advantage

Issue: The need to restore a natural fertile soil and city landscaping.

Solution: Use innovative agricultural technologies for landscaping large desert areas.

Restoring fertile soil on the territory of the Linear City, capable of providing the residents with natural products grown in the gardens within residential areas and on the roofs of private houses (berries, fruits, vegetables, salads, etc.) on the high-quality natural soil without the use of GMOs, chemicals, herbicides and pesticides.

Creating natural fertile soil (5% humus delivered from Belarus, +95% local soil) in the territory of Linear City for growing gardens and creating parks, including on the roofs of buildings, putting up hedges and green pedestrian tunnels.

When mixed with local soil in certain proportions the humus soil reproduces and gives the soil black earth fertility and stimulates rapid plant establishment, growth and development of all planted trees, shrubs and plants, substantially reducing the need for irrigation.

Consumption of water when using the proposed technology is reduced 5—7-fold on average. This is due to the specific and unique property of accumulation and retention of moisture by the powdered soil. And by adding small amounts of a liquid activator to irrigation water the need for daily watering of plants and trees is eliminated, however, despite this, the roots get sufficient daily amounts of water and substances required for successful growth and development.

The cost of creating a 30-cm fertile soil layer on the area of 1 hectare (10 000 m^2) in the desert of Abu Dhabi:

1) Soil (humus) — 200 tons. Cost — 250 thousand USD (including the delivery from Belarus).
2) Activator — 500 liters. Cost — 5000 USD (including the delivery from Belarus).
3) Local soil (at 20/1 ratio with the restoring agent) — 4 000 tons. Cost (including local transportation and mixing) — 40 000 USD.

Total: the cost of creating a 30-cm fertile soil layer on the area of 1 hectare — 295 000 USD.

FYI:

The construction costs per 1 m^2 of asphalt city road average to 1500 USD.

The costs of creation of 1 m^2 of 30-cm thick natural fertile soil is 29.5 USD. (This soil will grow a garden that will bear fruit and serve to the benefit of the people for centuries. Its green plants will produce oxygen, capture dust, absorb the noise of the city, create micro-climate and provide the biologically active substances beneficial for health and needed by every city dweller — phytoncides that kill and inhibit the growth and development of bacteria, microscopic fungi, and protozoa).

This a is 50-fold difference!

Conclusion: it is extremely inexpedient to "bury" the city soil under the asphalt.

Fig. 21. Linear City with residential clusters and fertile soil in the ground and off the shore

The proposed technology can significantly reduce the need for irrigation water (tenfold), and, in some cases, completely abandon or significantly reduce the use of various kinds of chemical, mineral and organic fertilizers. It is recommended for use by the Ministry of Natural Resources and Environmental Protection of Belarus and the Ministry of Environment and Water of the United Arab Emirates.

FYI:

For the purpose of greening the roads connecting Abu Dhabi with the rest of the United Arab Emirates, the country has already spent USD 4.5 billion. 25 million date palms were planted, more than 700 million tons of costly irrigation water spent annually. A significant share of trees and plants planted using known and actively used technologies demonstrate poor establishment and periodic re-planting is required, which leads to permanent additional expenses for the same "green areas".

4. Noospheric benefit

Issue: The need to improve the quality of life of the residents.

Solution: Using SkyWay Technology for creating a naturel ecosystem for urban dwellers.

Increase life expectancy and quality for urban dwellers by creating environmentally friendly and comfortable environment for living in a metropolis.

Widespread landscaping of urban neighborhoods in arid regions by restoring or creating the natural soil (about 30 cm thick) for setting up public parks, gardens, lawns and flower beds.

Economic impact — reducing the cost of irrigation for restored areas (up to 10 times lower), lower costs to offset the advance of the desert onto the city, getting organic food, creating comfortable climate in the city.

Fig. 22. Linear City fragment featuring two SkyWay transport systems

Placing green gardens on the roofs and floors of high-rise buildings, connecting them with public areas. Economic impact — reducing the energy consumption of air conditioning due to the creation of a natural microclimate in the buildings.

Reducing the load on the urban environment, no construction of major highways that "bury" large urban areas under the asphalt. Economic benefit — saving the budget used for the construction of highways and overpasses, availability of high-priced urban areas.

Placing gardens on operated roofs of private low-rise houses and in the courtyards will provide protection from excessive heating of the premises (plants on the roof evaporate moisture and cool down the soil — like a human sweating when hot) and create a comfortable microclimate for the dwellings. The gardens will be grown on restored fertile soil 0.3—0.5 meter thick.

Technology for producing drinking water from the air through condensation of water vapors will cover the needs of a private house (villa) for water supply and irrigation of the greenery, while the air cooled by the condenser unit will condition the interior space of up 500 m^2. For this purpose a small special design unit will be installed on the roof or on the patio.

Producing 500 liters of drinking and irrigation water per day will require a 3 kW unit powered by solar panels. At the same time operating costs of the system will amount to 3.5 USD per day, while creating an autonomous, cost-effective and environmentally friendly wellbeing system.

Economic impact — substantial reduction of the cost of cooling for dwellings (given that soil and vegetation layer on the roof is a natural thermal insulator).

Fig. 23. A green villa version

5. Socio-economic benefit

Issue: The need to save energy.

Solution: SkyWay transportation and infrastructure technology offers significant fuel (electricity) savings.

FYI:

Only one percent of the population of Abu Dhabi is using public transport. At the same time in Dubai public transport is used by about 11 percent of the residents, that is due to the broad choice of public means of transport in the Emirate, including the metro, buses and water taxis, as well as to a long-standing affection of UAE residents to personal motor vehicles and relatively affordably priced fuel and vehicles.

Reducing the losses of the city budget and household budgets from the daily traffic jams on the roads of megacities (the employer and the employee sometimes spend up to 1.5—2 hours of time per day commuting, that means the loss of at least 20 million USD per day for cities with a population of about 2 million people (600 million USD per month/USD 7.2 billion per year), and for one citizen — minimum 20 USD per day (600 per month USD / 7200 USD per year). When developing urban logistics in the Linear City modality, home-to-work commute will take no more than 15—20 minutes from anywhere to anywhere in the city (with only one connection at the intersection of the longitudinal and transverse overhead tracks).

Economic impact — residents save up to 1—1.5 hours of their time per day, which translates into to 10—15 USD in monetary terms. The daily travel from home to the city's overhead transport station will average no more than 200 meters, while the residents of the Linear City towers-stations will only need to take the elevator to the SkyWay transport platform to start their commute. Economic impact — about 90% saving on transportation costs.

Thee will be no need for daily expenses on fuel for the car and its maintenance. Economic impact — road transport costs are eliminated (fuel/maintenance/repair), which will save each family from 200 to 500 USD every month. And the sale of redundant vehicles will bring a few dozens of thousands of dollars back to the family budget. In addition, environmental issues created by mass motorization of the cities will disappear, including smog. Safety of the city will improve, as there will be no fatal accidents in the streets involving residents, including children.

Fig. 24. A variation of the elevated SkyWay city line

FYI:

Up to 1.5 million people die on the roads of the world every year and 15 million get injured, disabled and crippled, half of them — in the cities.

6. Logistic benefit

Issue: The need to reduce transport costs and improve logistics.

Solution: The innovative SkyWay approach to infrastructure can significantly improve logistics and reduce the cost of any development project.

Providing efficient, fast and inexpensive transport links between neighboring islands via overhead string-rail roads passing through the high-rise buildings. In addition, it is suggested to build a central road bridge using string technology for the movement of vehicles from the mainland to the islands. Such string bridge with asphalt pavement will be 2—3 times cheaper than conventional bridges.

Fig. 25. Linear City fragment

The site chosen as one of the options for the construction of the Linear City is the Al Hudayriat Island stretched from west to east, 14 km long and about 2 km wide. The island of about 2 800 hectares, which can accommodate about 100 Linear City blocks (clusters) 500×500 m each. The estimated population of the city is about 350 000 residents. The standards for green landscaping that currently stipulate 23.4 m^2 per person, will be not only met in such city, but exceeded 3 times over — about 70 m^2/person.

If this territory had conventional urban development project, the residents would need about 40 million vehicles to move across the island, each polluting the ambient air.

Currently automobiles cause about 70—80% of the urban air pollution. On average, one vehicle produces (kg/year): carbon monoxide — 135, nitrogen oxides — 25, hydrocarbons — 20, sulfur dioxide — 4, particulate matter — 1.2, benzopyrene — 7—10.

New generation of overhead transport is free from these shortcomings, while offering the density of transport routes incomparable with conventional transportation.

Development project for the construction of one Linear City block (cluster) has the following characteristics:

1) Linear dimensions of the block — 500 × 500 meters (25 ha). At the corners there are four tower-stations connected by string-rail high-altitude tracks.
2) The central part of the block has low-rise detached houses — 250 one-storey (or two-storey) houses each sitting on 8-are land plot (about 20 × 40 m). The total housing area is 50 000 m^2 (for the one-story buildings) or 100 000 m^2 (for two-storey building). This residential areas can house about 1 000 people (one house per the average family of 4).
3) The roof of each private house is a flat area of about 200 m^2, covered with a 30—50 cm thick layer of soil with a private custom-designed garden. The total green area, including the patios, will make 16 hectares (green coverage ratio about 80%).
4) A green fence is put up along the perimeter of the residential area to prevent the flow of hot air masses and create a comfortable microclimate in the block.
5) One high-rise tower station (30—50 floors, diameter 30—40 meters) includes two passenger station (adjacent floors), 200—250 m^2 each. The total area of the premises is about 40 000 square meters (about 20 thousand m^2 of living quarters and 20 thousand m2 of commercial spaces). The tower can accommodate about 1 000 people (250 apartments with an average area of 80 m^2). The tower offer daily working space for around 2 000 people (at the rate of 10 m^2 of office space per employee). The total number of people daily visiting the tower and inhabiting it is 3 000.
6) The number of residents of high-rise buildings in one block — from 2 000 people, the number of people coming in daily for work — 4 000 people.

7) The total population of the city block — from 3 500 people.
8) The territory allotted for the public road for special vehicles and for sidewalks — 3 hectares.
9) The area allotted for high-rise buildings — 2 hectares.
10) The total area allotted for green landscaping (including roofs) — 22 hectares.
11) Infrastructure (electricity/water/sanitation) — city grid or autonomous.

The total development area of one cluster block is about 100 000 m^2 of residential and commercial properties.

7. Infrastructure benefit

Issue: The need to harmonize the city's infrastructure within common quality standards.

Solution: Introduction of SkyWay transport and infrastructure system.

SkyWay urban development and municipal logistics meet the highest Estidama Pearl Rating standards.

All high-rise buildings (on average, 40 floors each) are spaced at 500—800 meters at the intersection of transport lines. Each tower is connected with four adjacent tower stations via overhead string tracks, which enable comfortable and safe transit of passengers between stations at 90 km/h. Capacity of the logistics hub with two stations is up to 1 mln passengers a day. By increasing the distance between the tower stations (more than 1 km off each other) the pace of public transport can be increased up to 120—150 km/hour.

Fig. 26. SkyWay Linear City

Buildings are erected in accordance with the Estidama Pearl Rating buildings and projects assessment system aimed at conserving natural resources and the

environment of the country through the introduction of specific construction standards. Linear City seeks to receive the highest Estidama rating.

The tower station with 30—50 floors features both residential properties and administrative and technical facilities, as well as green recreation areas (one of possible layouts):

1st floor — parking for electric cars and bicycles,

2nd floor — shopping centers and services,

3rd floor — kindergarten and school (scaled to the number of residents of the cluster),

4th floor — medical center (scaled to the number of residents of the cluster),

5th floor — educational center and conference rooms,

6th floor — fitness center,

7th floor — restaurants and shopping areas,

8th—19th floors — residential properties (each the fifth floor — recreational area, featuring green areas, cafes/restaurants),

20th floor — linear transport station,

21st floor — transport station for the transverse line,

22nd floor (and subsequent floors) — offices (every fifth floor — recreational area, featuring green areas, cafes/restaurants).

Educational and medical facilities may be located in one of the 4 neighboring towers.

Towers stations located off the shore (on the pile foundation) feature an above-water terrace with a park created on a 0.5m-thick layer of fertile soil (concrete slabs of the platform have recesses for the tall trees). Along the perimeter of the "island" — a marina for smaller yachts and boats, the tower features hotels and residential apartments, as well as spa facilities and game centers, luxury real estate, office premises.

Fig. 26. Bird’s-eye view of the island platform and the tower

The main feature of marine towers — clear waters of the surf and no urban smog (absorbed by the sea) — makes them the perfect place to live and stay. Meanwhile, the sea hydrology is not affected by the pile-supported island (it will be cheaper than filling island) and, correspondingly the established sea currents are not disrupted, nor fish migration routes and habitats violated.

Furthermore, the island can be encircled by a mesh fence to create a sea plantation for growing aquatic cultures — fish, crustaceous, mollusks, algae — in in their natural habitat with corresponding aquatic technologies — without GMO or antibiotics.

Fully automated (unmanned) overhead urban transport, clean and silent, traveling as high as birds fly, will provide the highest level of safety and comfort in the Linear city both on land and sea.

Sophisticated transport logistics will enable fastest travel over long distances with only one connection between stations on the adjacent floors only of 4 m off each

other. The distance between adjacent high-rise buildings is covered in 1—1.5 minutes with SkyWay horizontal lifts.

Low cost of overhead transportation, and if the cost of the transport system is included in the cost per square meter of housing and into utility bills, public transport will be virtually free for the Linear City residents.

Fig. 28. Bird's-eye view of the offshore SkyWay Linear City (sea depth up to 25 m)

The capacity of the transport network is much higher than 1 million passengers a day (at night it will haul goods for shopping centers, offices and catering facilities located in the high-rise buildings).

8. Alternative energy benefit

Issue: The need to reduce energy costs.

Solution: All SkyWay technologies can use renewable energy.

Reduced energy consumption in Linear City office buildings due the widespread use of solar panels on the facades of high-rise buildings (up to half of the facade area).

Fig. 29. A variation of the SkyWay tower station

Electricity consumption in private homes of the Linear City residents shall be reduced due to multifold reduction of energy consumed for air-conditioning and to installation of solar panels and collectors and on the surfaces of roofs, walls and fences of private households.

Reduced energy consumption is due to the layer of soil with vegetation on the roof of one-storey private house being a natural conditioner — both due to high thermal insulation of the surface exposed to the sun and high level of heat retention (by the soil) and due to evaporation of moisture by the soil and vegetation.

Power supply to urban string-rail transport is provided by installing solar panels above the track mounts and on the towers themselves (in case of high-rise track tower buildings serve as the track towers), as energy consumption by SkyWay transport is 70—90 times lower than that of motor transport for the same

performance, and 18 times lower than that of tram lines (see above: Benefit 1, Overpass with slacking track). Therefore, solar panels will be sufficient to fully cover the energy needs of the Linear City transport. In addition, wind power will be utilized via installing vertical-axis wind turbines on the roofs of high-rise buildings.

Fig. 30. Two-level connection station in SkyWay high-rise tower

9. Safety benefit

Issue: The need to improve security systems. Road accident fatalities and the burden of traffic accidents on the budget.

Solution: SkyWay rolling stock uses the "second level" track eliminating the risk of deaths on the roads.

In addition to transport security, SkyWay also enhances anti-terrorist safety and fire safety of tall buildings by integrating a system of horizontal lifts.

Fig. 31. Linear City fragment featuring two SkyWay transport systems — horizontal lifts — mounted (elevation about 10 m) and suspended (elevation about 100 m)

Horizontal lifts connecting adjacent buildings shall substantially reduce the time of evacuation of tenants in the event of fire or explosion — currently real time period for evacuation of a 50-storey building is about 3 hours, while using the horizontal high-rise lifts going out 4 ways the evacuation time will be reduced to 30 minutes.

In addition, the horizontal lift will enhance the fundamental strength of high-rise buildings and stability in case of terrorist attack and bombing, as the track structure will act as steel strings anchoring the tall building from the sides and preventing it from slanting. Even in the event of the fall (collapse) of a building, for example, in the

case of military action, it will not hit the neighboring tower, as all high-rise buildings are placed at a substantial distance off each other.

Dispersed placement of high-rise buildings will prevent crowding of people and the related issues — the need for daily commute of a large number of passengers, movement of goods, food, etc., as well as the removal of large volumes of all kinds of waste. Never mind that high-rise buildings in the Linear City are actually located closer to each other than the traditional skyscraper center. For example, in order to get from the 20th floor of a building to the twentieth floor of a nearby building located at 500—800 meters, SkyWay city resident will need 1—1.5 minutes, while in the traditional high-rise buildings cluster where the skyscrapers are at 50 m from each other this would take about 10 minutes.

The track structure of the horizontal lifts can also bear the redundant (or main) power cables and fiber-optic communication lines between the high-rise buildings.

10. Civilization benefit

Issue: The need to develop desert areas, protect the city from the advance of the desert, create an urban environment comfortable for living.

Solution: Development of the desert area adjacent to the luxury coastal development of Abu Dhabi and creation of a unique urban project — the world's first Linear City with an integrated "second level" public transport system.

Fig. 32. Linear City in place of the former desert, with residential clusters on the shore, on islands and off the shore

Linear City is a cluster-type urban settlement, where the surface of the earth is meant for pedestrians and green plants, while transport, energy and information networks are placed above the ground on the "second level".

There is only one mode of transportation in the city — horizontal lifts connecting the high-rise towers, spaced at 500 meters and more (up to 3 km) from each other and placed along one line or several parallel and intersecting lines.

The basic principle of the construction of each infrastructure cluster is that it is a pedestrian quarter, in which comfortable low-rise buildings are put between the multi-functional high-rise buildings connected by a horizontal lift, with widespread landscaping of urban areas and use of renewable energy sources.

Characteristics of the cluster-type urban settlement:

- Footprint: 25 hectares (the distance between tower stations 500 m);
- Population: 5—10 thousand people;
- In the center of the cluster (or in its corners) there is a multi-purpose shopping and entertainment centerpiece building, incorporating SkyWay overhead transport stations, within walking distance from the residential properties;
- Low-rise residential properties located within walking distance to the centerpiece building.

Fig. 33. SkyWay Linear City