
SW
SkyWay
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SW
INNOVATIVE SKYWAY
TRANSPORT AND INFRASTRUCTURE
TECHNOLOGIES


SW

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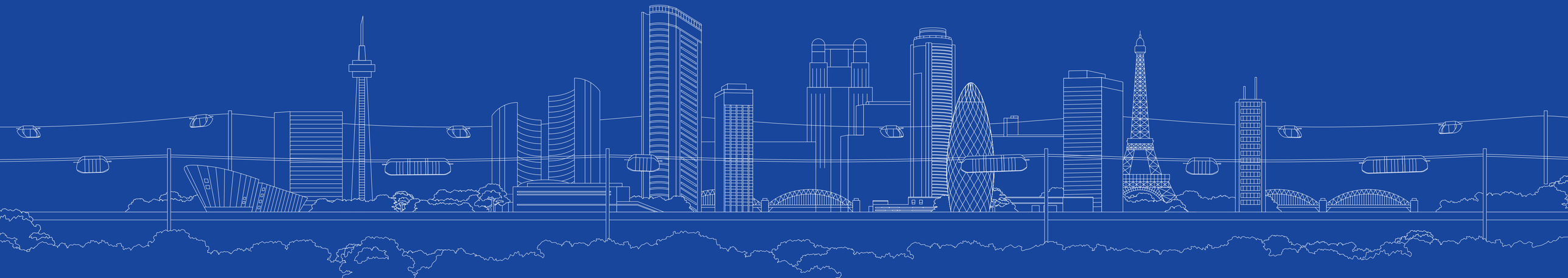
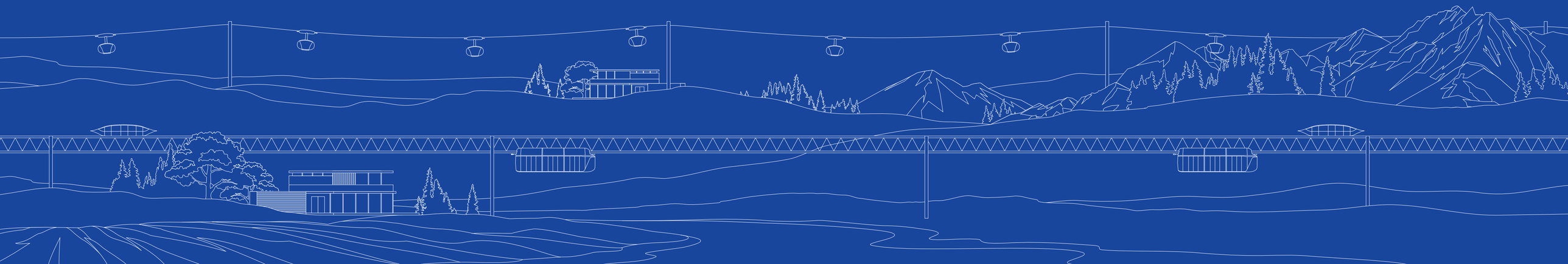
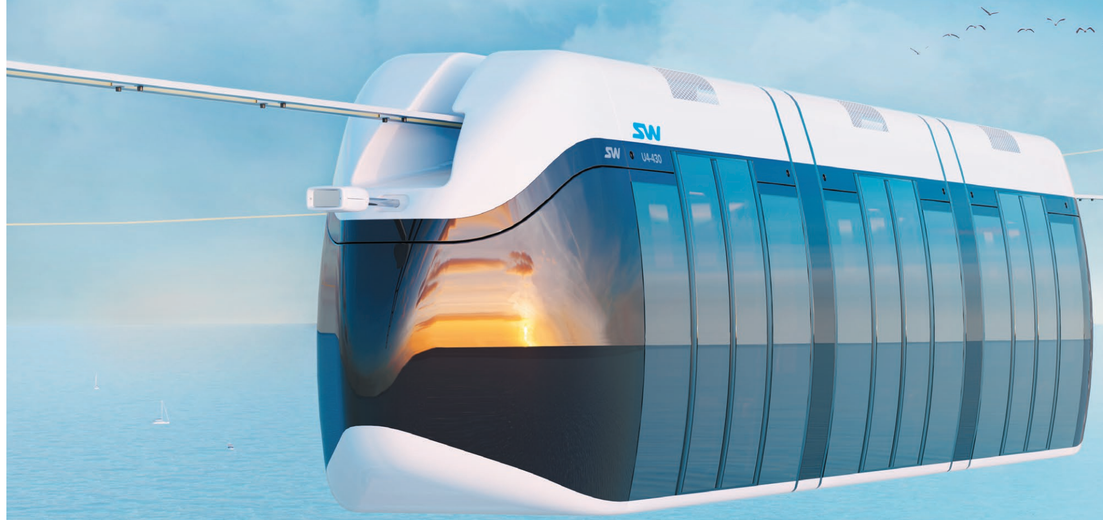




SKYWAY
PHILOSOPHY

Transport should be a solution to problems, not their source.

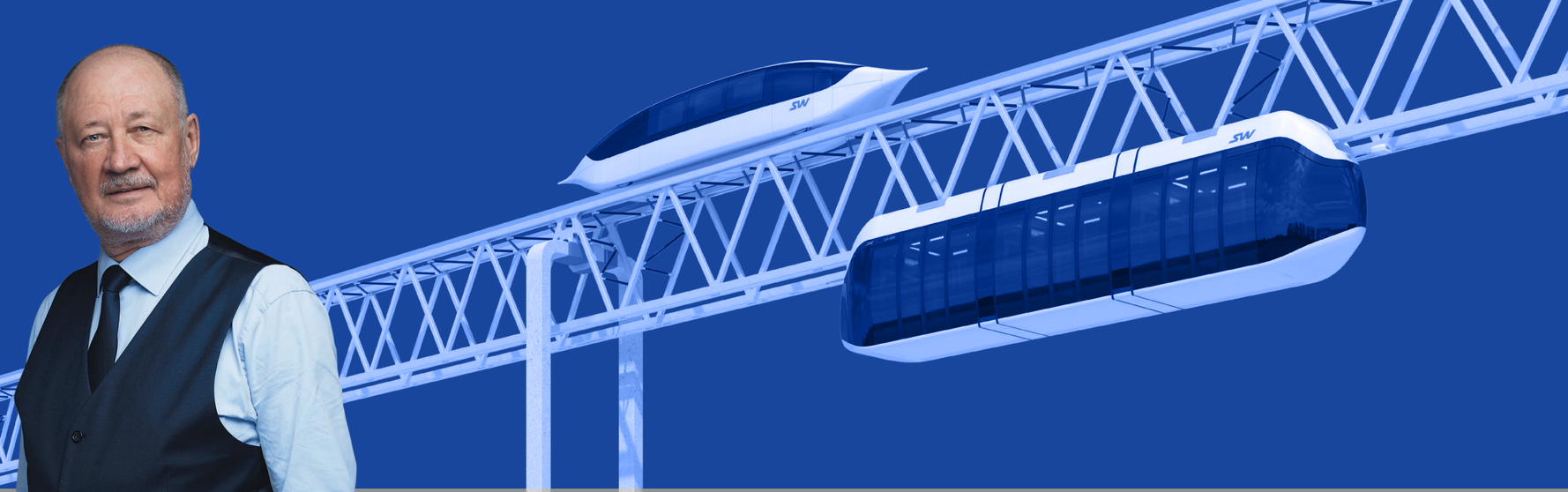
The SkyWay system provides passenger and cargo transportation in a separate space – on the "second level" above the ground.



The fact that SkyWay vehicles move above the ground on a specially designed rail-string overpass ensures a number of advantages: optimized aerodynamics, increased speed, unprecedented safety, rational use of land and resources, minimized environmental damage caused by transport. In addition, the cost of construction and operation is significantly lower compared to the existing transport solutions.

THE SKYWAY SYSTEM: OPTIMAL, EFFECTIVE AND SAFE

Anatoli Unitsky



Scientist and inventor, author of more than 200 scientific papers, 20 monographs and over 150 inventions in the field of construction, transport, mechanical engineering, electronics and chemical industry.

Creator of SkyWay and geocosmic transport systems, as well as a number of transport and infrastructure projects based on the string technology.

Head of two UN projects (1998, 2002), member of the USSR Cosmonautics Federation.

President of SkyWay Group of Companies. General Designer of SkyWay Technologies Co.

SkyWay is the concept of an elevated transport system, which has no analogues in the world.

MAIN COMPONENTS OF SKYWAY TRANSPORT AND INFRASTRUCTURE COMPLEX

- Uncut pre-stressed rail-string overpass.
- Unmanned rail electric vehicles on steel wheels: highly aerodynamic, equipped with an anti-derailment system and intellectual safety, power supply and communication systems.

SKYWAY TECHNOLOGIES CO.

The development of SkyWay transport and infrastructure complexes is carried out by the team of engineers and designers of SkyWay Technologies Co. (Republic of Belarus).

COMPANY STRUCTURE

- 22 Design Offices
- Rolling-Stock Department
- Department for Overpass Structures, Tooling Components and Test Equipment
- Project Management Department
- Special Design and Technological Office with Pilot Production
- Technological Department
- Quality Control and Inspection in Engineering
- Department for Advanced Studies and Developments
- Office of Chief Engineer
- Capital Construction Department
- Test Centre
- EcoTechnoPark
- Business Development Department
- Department of Information Technology
- Procurement and Logistics Department
- Bio- and Agricultural Technologies Department
- Design and Architecture Department
- Human Resources Department
- Accounting and Reporting Department
- Patent and Licensing Services

SKYWAY PRODUCTION FACILITY

Its purpose is to develop and test the most important technological solutions, main know-how of SkyWay.

Special Design and Technological Office with Pilot Production performs the complete cycle of operations connected with production of SkyWay rolling-stock.

Manufacture
component parts, devices, components

Testing
mechanical assemblies and electronic devices

Trial Run
production prototypes

MAIN
TRANSPORT SOLUTIONS

The SkyWay systems can meet a wide range of transportation demands offering a possibility of highly efficient passenger and cargo transportation for any distances under any natural and climatic conditions.

SkyWay

- Speed, safety, comfort, affordability, cost effectiveness, sustainability.
- Increased social activities for people.
- The basis for the information, power, transport and communications network of a new generation.

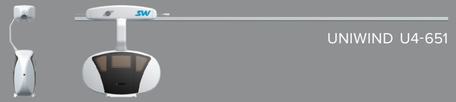
All types of SkyWay systems are distinguished by energy efficiency, minimal adverse environmental impact and a high safety level of passenger and cargo transportation.

PASSENGER TRANSPORT

UNIBUS U4-210

UNIBUS U4-220

UNICAR U4-430

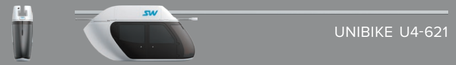


UNIWIND U4-651

UNIBUS U4-210-T2

UNIBUS U4-220-T2

UNICAR U4-430-T3



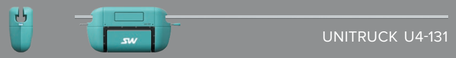
UNIBIKE U4-621

UNIBUS U4-210-T3

UNIBUS U4-220-T3

HIGH-SPEED
UNIBUS U4-362

CARGO TRANSPORT



UNITRUCK U4-131

UNITRUCK U4-171

UNICONT U4-192-01

UNITRANS U4-100

PASSENGER
TRANSPORT

The SkyWay transport is a unique infrastructure solution for cities and suburbs. The vehicles developed on the basis of SkyWay technology were built using a principle of modular construction, which allows selecting the optimal rolling stock with minimal costs.

It fits harmoniously into the existing infrastructure of any megacity.

It helps to solve the transport problems of big cities by means of creation of the of high-rise buildings network having over the ground (air) transport communication.

Designed for city and intercity passenger transportation.

UNIWIND

**Monorail, suspended,
light transport vehicle
of small capacity.**

Due to its construction with maximum functionality, simplicity of use and low cost of production and minimal power consumption, the uniwind is one of the most affordable solutions for provision of the transportation links in sparsely populated and remote areas, as well as in the regions with challenging terrain.

The optional design of assemblies and components allows using this transport vehicle for transportation of passengers and cargo.

Cruise speed		Up to 150 km/h	
Maximum longitudinal slope of a track		Up to 15 % (special version – up to 30 %)	
Single transport vehicle		**Couplings**	
Passenger capacity	2	Maximum number of uniwinds in a coupling	7
Performance	Up to 720 passeng./h (roundtrip)	Performance	Up to 3,500 passeng./h (roundtrip)
Interval between vehicles	20 s	Interval between couplings	30 s

UNIBIKE

**Monorail, suspended,
light passenger transport vehicle.**

It combines features of the highly effective electric vehicle of transportation system and sports and entertainment unit.

In addition to the on-board (external) source of energy, it is equipped with bicycle generator, due to which unibike can be driven in motion by muscular power of the passengers.

In the future, it can be an alternative to a car, bike and motorcycle.

Cruise speed		Up to 150 km/h	
Maximum longitudinal slope of a track		Up to 15 % (special version – up to 30 %)	
Single transport vehicle		**Couplings**	
Passenger capacity	2	Maximum number of unibikes in a coupling	7
Performance	Up to 720–1,400 passeng./h (roundtrip)	Performance	Up to 3,500–6,300 passeng./h (roundtrip)
Interval between vehicles	20–25 s	Interval between couplings	30–40 s

UNIBUS

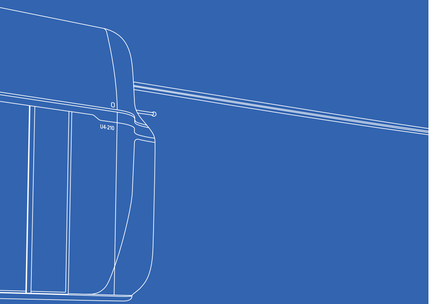
Passenger transport vehicle.

It is designed for city and intercity transportation and has different versions (mounted or suspended, double-rail or monorail); design and layout are determined by design features and customer requirements.

The unibus can be a single vehicle (as a car or bus), as well as a train with different number and type of units.

It is equipped with climate control system, audio and video information system for passengers and other additional functions. The cabin has special seats for disabled persons.

Cruise speed		Up to 150 km/h	
Maximum longitudinal slope of a track		Up to 15 % (special version – up to 30 %)	
Single transport vehicle		**Couplings**	
Passenger capacity	10–80	Maximum number of unibuses in a rigid coupling	3–7
Performance	Up to 2,500–12,000 passeng./h (roundtrip)	Performance	Up to 12,500–35,000 passeng./h (roundtrip)
Interval between vehicles	30–50 s	Interval between couplings	40–50 s



The unibus has smooth natural lines and combines the efficiency of urban environment with the emotions of surrounding community, the logics of functionality with futuristic appearance.

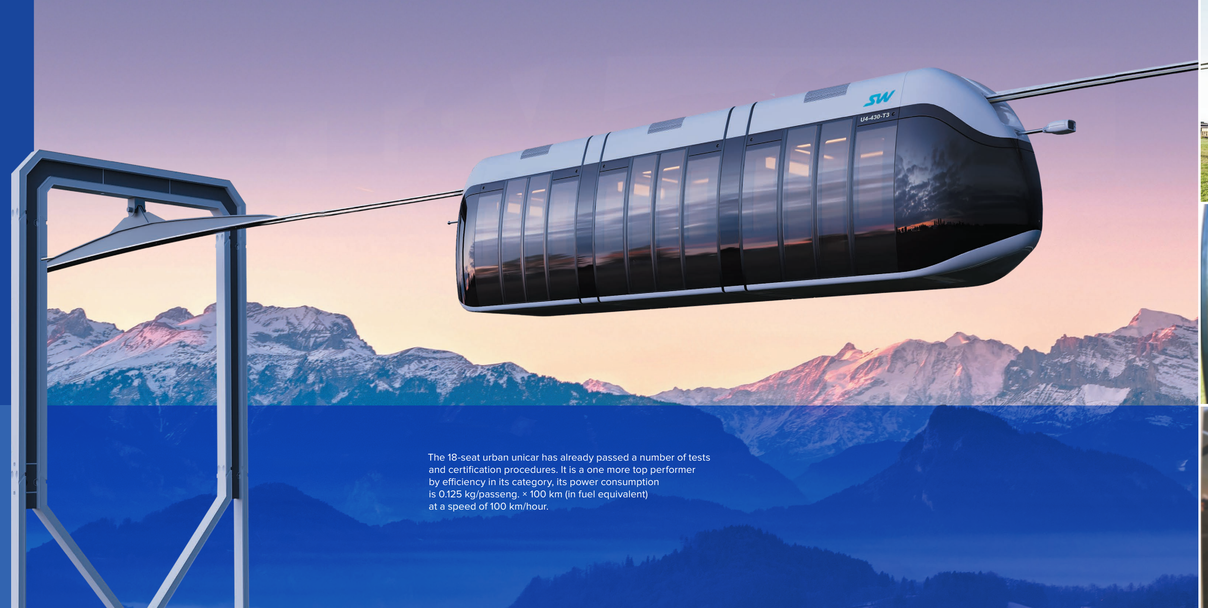
UNICAR

Monorail, suspended, passenger transport vehicle.

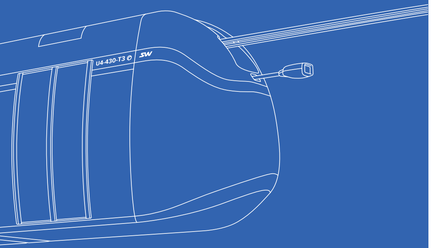
It is a stylish and comfortable vehicle, which helps to unclog the streets of a town or a city.

It would ensure more significant traffic capacity than more impressive by the size, cost and capacity railway trains and airbuses (jumbo planes), which mainly due to their dimensions are unable to have short headways between each other.

Cruise speed		Up to 150 km/h	
Maximum longitudinal slope of a track		Up to 15 % (special version – up to 30 %)	
Single transport vehicle		**Couplings**	
Passenger capacity	6	Maximum number of unibuses in a rigid coupling	7
Performance	Up to 1,500 passeng./h (roundtrip)	Performance	Up to 7,000 passeng./h (roundtrip)
Interval between vehicles	30 s	Interval between couplings	43 s



The 18-seat urban unicar has already passed a number of tests and certification procedures. It is a one more top performer by efficiency in its category, its power consumption is 0.125 kg/passeng. × 100 km (in fuel equivalent) at a speed of 100 km/hour.



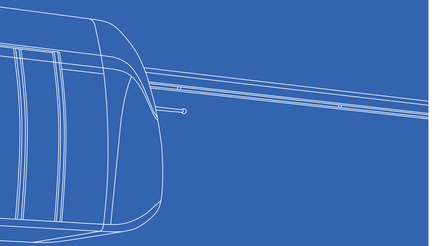
UNICAR MEETS
THE REQUIREMENTS OF TIME:

new look, new proportions, new rhythm.

UNICAR
(TROPICAL VERSION)

The unicar (tropical version), as a modification of the earlier built unicar, has got a number of improvements necessary for adaptation to hot climate conditions and increased humidity, as well as provision of the comfortable conditions for the passengers.

- Max. operating temperature: 50–60°C
- Temperature in the cabin: 20–23 °C.
- Duplication of all systems: independent drive of axles of transport vehicle, two climate-control units, two cooling units, two energy accumulators, two types of charging (manual and automatic).
- More powerful electric motors.
- Updated braking system.
- Hydraulic suspension.
- Entrance/exit doors are located on both sides of the cabin.
- Improved computer vision system.
- VIP-cabin: four seats (two VIP-armchairs, two pull-down seats (for personnel), folding table, TV set with 32" screen, refrigerator, cup (glass)-holder, more powerful speaker acoustic system.
- Improved door operating gear.
- Multiple glass units.



It is specially designed for operation under the tropical climate conditions of the Middle East.

HIGH-SPEED TRANSPORT

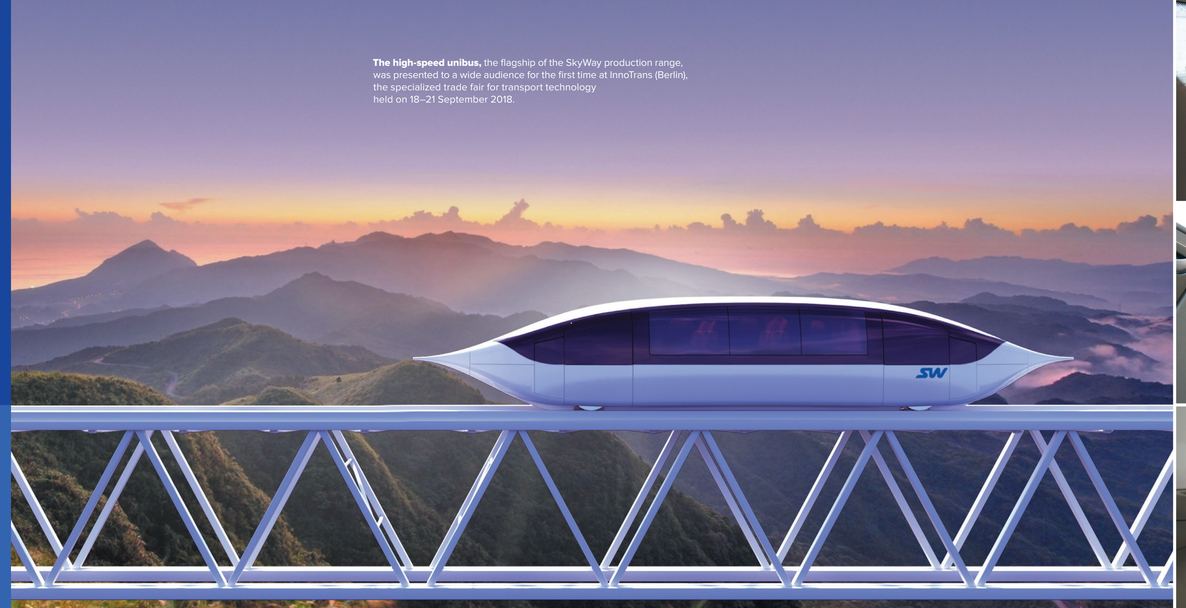
Mounted, passenger transport vehicle on steel wheels. It is designed for intercity passenger and cargo transportation for the distances of up to 10,000 km.

High-speed is provided by the specially designed string-rail overpass, flowing lines of the transport vehicle and its unrivaled aerodynamic properties. The aerodynamic characteristics of unibus U4-362 are close to the theoretical limit: aerodynamic drag factor C_x equals to 0.06 (for reference: C_x of Porche 997 is 0.28).

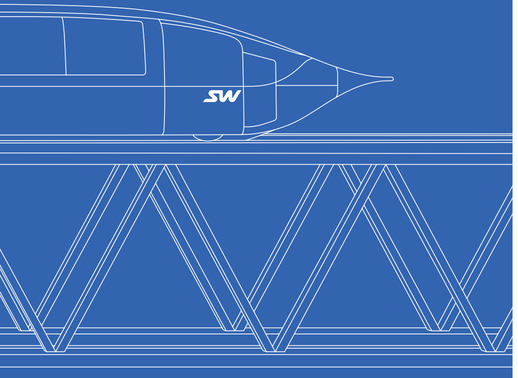
Equipped with luggage compartments.

Cruise speed		Up to 500 km/h	
Maximum longitudinal slope of a track		Up to 15 ‰	
Single transport vehicle		**Couplings**	
Passenger capacity	6–46	Maximum number of unibuses in an electronic coupling	18 unibuses of 46 passengers
		Performance	Up to 50,000 passeng./h (roundtrip)
		Interval between couplings	Up to 120 s

The high-speed unibus, the flagship of the SkyWay production range, was presented to a wide audience for the first time at InnoTrans (Berlin), the specialized trade fair for transport technology held on 18–21 September 2018.



HIGH-SPEED
UNIBUS



CARGO
TRANSPORT

Transport system designed for cargo transportation for the distances of 500 km and more.

The SkyWay cargo complexes provide a wide range of opportunities, especially in case of operation round the year under different climate and environmental conditions, in the remote and hard-to-reach places, in high-altitude and desert terrains, jungles and continental shelves.

SCOPE OF APPLICATION OF SKYWAY CARGO:

- **transportation of loose cargo** (ore, coal, construction materials, overburden rock, etc.);
- **transportation of break-bulk cargo** (containers, woods, metal, etc.);
- **transportation of liquid cargo** (crude oil and refined products, liquefied natural gas, natural drinking water, etc.);
- **transportation of special cargo** (cryogenic fluid, radioactive materials, explosives, weapons, etc.).

UNITRUCK

Monorail, suspended cargo transport vehicle.

It is distinguished by audacious design solutions, outstanding visual novelty and high functionality.

It is based on suspended urban passenger unibuses, consists of traction and cargo modules. Such a modular design allows using the unitruck in almost all spheres of cargo transportation.

It is intended for transportation of bulk, liquid, hazardous, perishable and break-bulk cargo. Loading and unloading of the unitruck is carried out automatically.

The intelligent control system ensures the movement along the rail with minimal acceptable safe time interval, which maintains high performance of the complex.

If required, the unitruck can be combined with the unitrans, which significantly widens the range of its application.

Cruise speed	Up to 150 km/h
Performance	Up to 100 mln tons/year
Maximum longitudinal slope of a track	Up to 15 % (special version – up to 30 %)

UNICONT

Monorail and double-rail, mounted, automatic, self-propelled, cargo transport vehicle.

Cruise speed	Up to 120 km/h
Performance	Up to 5 mln TEU/year
Maximum longitudinal slope of a track	Up to 5 %

It is intended for transportation of marine freight containers with nominal length of 20 and 40 feet by string truss structure.

Field of application: transport logistics hubs and port infrastructure facilities. Loading and unloading of containers into the unicont can be carried out both in special terminals, by means of a portal bridge crane or reach-stacker. The unicont design allows transporting different types of oversized containers without additional overload.

UNITRANS

Double-rail, continuous cargo transport vehicle.

It is an optimal solution for the mining sites and arrangement of loading-unloading terminals and seaport terminals. It allows carrying out fast and affordable transportation of the significant volumes of bulk materials. The loading to the belt conveyor of the unitrans is carried out from a special terminal, unloading – by tilting of the belt in vertical plane. It can operate twenty-four-hour, all year round.

Cruise speed	Up to 36 km/h
Performance	Up to 100 mln tons/year
Maximum longitudinal slope of a track	Up to 30 % (special version – up to 45 %)

SKYWAY
SEA PORT

MAIN ADVANTAGES OF USING SKYWAY CARGO TRANSPORT SYSTEM IN A SEA PORT:

- delivery of cargo (loose, liquid and break-bulk) for the distance of 5–10 km and more from the shore;
- mooring of large vessels does not require the creation of quay walls, dredging or shore reinforcement;
- it is possible to deliver goods to a sea port located in the natural depths (up to 25 m);
- a port and the SkyWay transport system form a single logistics complex for the delivery of cargo;
- the type of transportation – from a mining enterprise to a bulk carrier's hold without intermediate stocking.

LINEAR CITY:
IN UNITY WITH NATURE

SkyWay tracks contribute to the development of linear cities – cluster-type urban settlements harmoniously integrated into the environment.

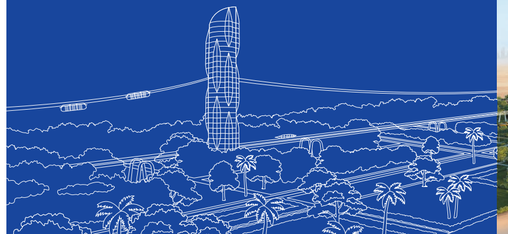
SkyWay linear cities can be built in the mountains, on desert and flooded territories, including in areas with challenging terrain and on the sea shelf.

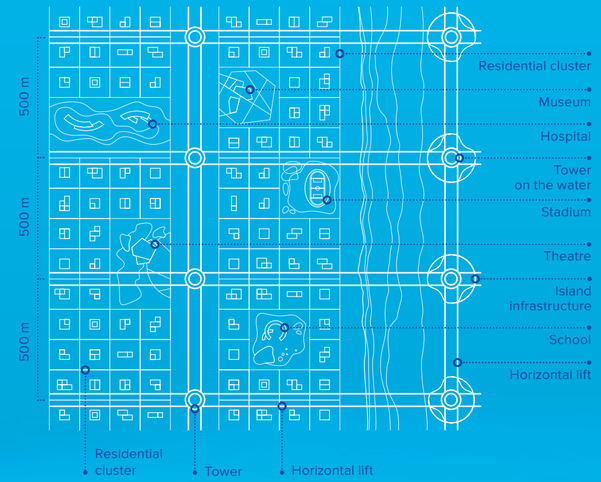
The construction of linear cities will not require cutting down forests, building motor roads and railways or disturbing biogeocenosis in the construction zone in any similar way.

Innovative approach to the construction of urban settlements in accordance with the logic of SkyWay linear cities has a number of advantages in comparison with traditional housing.

The ground surface is intended for pedestrians to walk and plants to grow, whereas transport, power and information communication lines are located above the ground at the "second level".

The key element of the system are horizontal lifts (SkyWay tracks) connecting neighboring multifunctional high-rise buildings. Low-rise comfortable buildings with all-round greening of urban areas are located between the dominant towers.



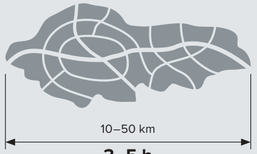


LINEAR CITY

- Increasing personal space and communication with the external environment.
- High quality of life.
- Focusing on the quality of the built housing.
- Increasing reputation of the territory and investment attractiveness.
- Transport accessibility.
- Pedestrian city.

TRADITIONAL HOUSING

- Low quality of living environment and living standards in general.
- Negative impact on humans and nature.
- Reduction of the inhabitants' mobility.
- Focusing on the number of square meters in the deliverable housing.
- Road accidents, traffic jams, smog.



ECOHOUSE:
HOUSE OF THE FUTURE TODAY

The time of faceless identical buildings has passed. A man needs eco-friendly architecture being a source of daily spiritual joy. The society has come to the conclusion that people should not conquer the nature, but live with it in full harmony and mutual understanding.

ECO-FRIENDLY

Ecohouse is built using "green" technologies, as well as environmentally friendly materials that do not harm the nature. A project considers cardinal points, wind rose, landscape, human-friendly zoning of internal premises and overall geometry of building construction.

COST-EFFECTIVE

Ecohouse is provided with heat, electricity and hot water using renewable energy sources – sun, ground, wind. An integrated approach when designing a building naturally uses renewable energy systems as constructive design elements.

AESTHETIC

The development of "green" technologies gives the opportunity to create beautiful, multifunctional, environmentally friendly admirable ecohouses. An original step towards the reproduction of natural balance – roof gardening – is not only a good view of the roof, but also a sky-high part of the terrestrial ecosystem.

MAIN TECHNOLOGICAL ELEMENTS

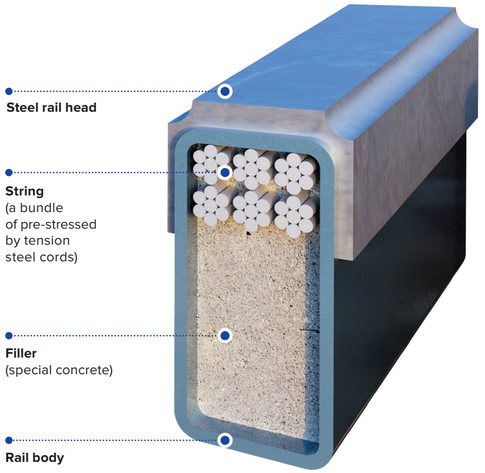
THE BASIS OF SKYWAY TECHNOLOGY – AN INNOVATIVE STRING RAIL

String rail or rail-string is a conventional uncut (along the length) steel, reinforced concrete or steel-reinforced concrete beam or truss equipped with a rail head and additionally reinforced with pre-stressed (extended) strings.

A string rail is a combination of the characteristics of the flexible thread (at a long distance between anchored supports) and rigid bar (at a small beam span — under a wheel of rail transport vehicle and above the support).

A flat head of the rail and cylinder steel wheel ensure minimal consumption of the energy for the movement.

VERSION OF SEMI-RIGID STRING RAIL

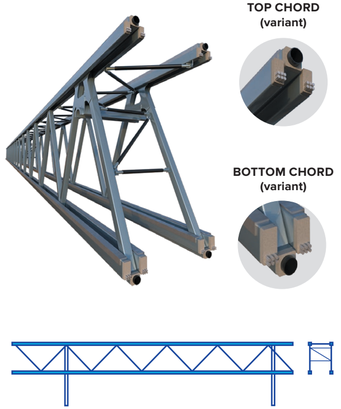


TYPES OF STRING RAILS

AND CORRESPONDING DESIGNS OF TRACK STRUCTURE

RIGID RAIL (TRUSS)

Rigid uncut track structure



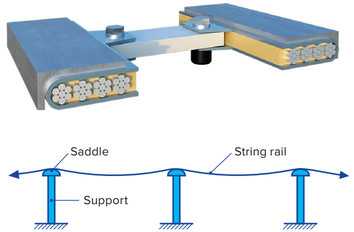
Motion speed:
from 100 to 600 km/h.

Relative structural rigidity:
1/1,000–1/10,000.

Track structure curve radius:
r = 5,000... 50,000 m.

FLEXIBLE RAIL

Flexible uncut track structure (variant)



It is not an analogue to the cable railway:

- use of rail (lower rolling resistance);
- lower energy consumption for movement (by 3–5 times);
- possibility of using a gravity engine during the movement downward and gravity brake during the movement upward (reduce energy consumption by another 3–5 times);
- high durability (by 5–7 times higher).

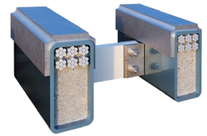
Motion speed:
from 30–60 (on support) to 120–150 km/h.

Relative structural rigidity:
1/100–1/500.

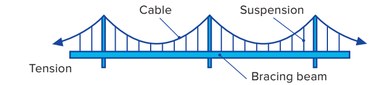
Track structure curve radius:
r = 100 (on support)... 2,000 m.

SEMI-RIGID RAIL

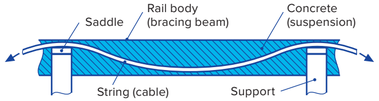
Semi-rigid uncut track structure



Suspension bridge



Track structure design follows the design of a suspension bridge, combining its all main elements.



Motion speed:
from 50 to 250 km/h.

Relative structural rigidity:
1/500–1/2,000.

Track structure curve radius:
r = 500... 5,000 m.

Power of rolling resistance of a wheel of unibus with weight of 5,000 kg at a speed of 450 km/h:

$P_{rr} = m \times g \times C_{rr} \times v = 5{,}000\ \text{kg} \times 9.81\ \text{m/s}^2 \times 0.0015 \times 125\ \text{m/s} = 9.2\ \text{kW}.$

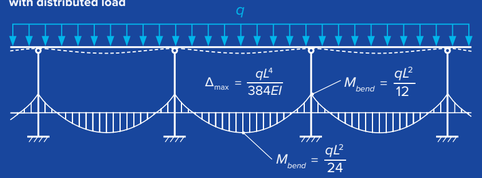
For reference:
in case of use of pneumatic machine with $C_{rr} = 0.18$ (for $v = 450$ km/h)

$P_{rr} = 1{,}100$ kW.

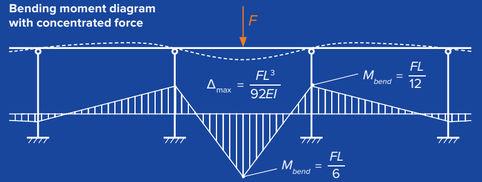
SKYWAY TECHNOLOGY AND CONVENTIONAL BEAM OVERPASS

INNOVATIVE UNCUT PRE-STRESSED RAIL-STRING OVERPASS (SKYWAY TECHNOLOGY)

Bending moment diagram with distributed load



Bending moment diagram with concentrated force



10 %

of load in a SkyWay overpass – its own weight. The overpass carries the useful load, not itself in contrast to conventional bridges.

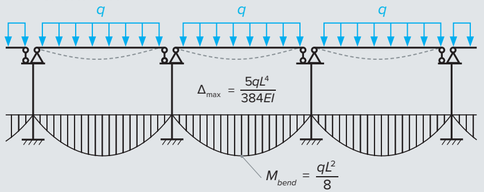
With equally distributed load, the SkyWay overpass is 5 times more rigid (smoother) and 3 times stronger than a conventional bridge.

With equally concentrated force, the SkyWay overpass is 1.9 times more rigid (smoother) and 1.5 times stronger than a conventional bridge.

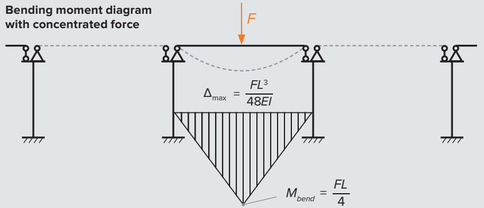
The SkyWay overpass decreases the amount of building materials required for its construction compared to a conventional overpass. As a result, the construction cost is significantly reduced.

SPLIT OVERPASS (CONVENTIONAL BRIDGE)

Bending moment diagram with distributed load

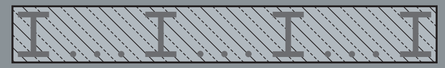


Bending moment diagram with concentrated force



90 %

of load in a conventional overpass – its own weight. The overpass carries itself, not useful load.



A solid roadbed gives additional load on supports and has a high cost.

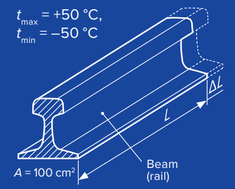
PRE-STRESSED SKYWAY STRING TRACK –

an optimal solution to compensate thermal distortion

Under thermal effect:

– absolute deformation
$\Delta L = \alpha \times L \times \Delta t$;

– relative deformation
$\varepsilon = \frac{\Delta L}{L} = \alpha \times \Delta t$.



For steel,

linear expansion
thermal coefficient (per 1 °C)

$\alpha = 0.000012$;

with Δt = 100 °C, ε = 0.0012 = 1/833
(the extension will be 1.2 m per 1 km).

TEST OF A RIGIDLY RESTRAINED BEAM FOR STRENGTH AND STABILITY UNDER EXPOSURE TO TEMPERATURE (Δt = 100 °C)

Without tension

Compressive buckling.

With tension

The beam is not subject to compressive buckling (with $N \geq R$).

Strength test:

– compression strain of longitudinal fibers:
$\sigma = E \times \varepsilon = E \times \alpha \times \Delta t \leq \sigma_{02}$.

For steel,

with $E = 2 \times 10^5$ MPa and Δt = 100 °C:
$\sigma = 2 \times 10^5 \times 0.0012 = 240$ MPa (ca. 2.4 t/cm²).

Stability test:

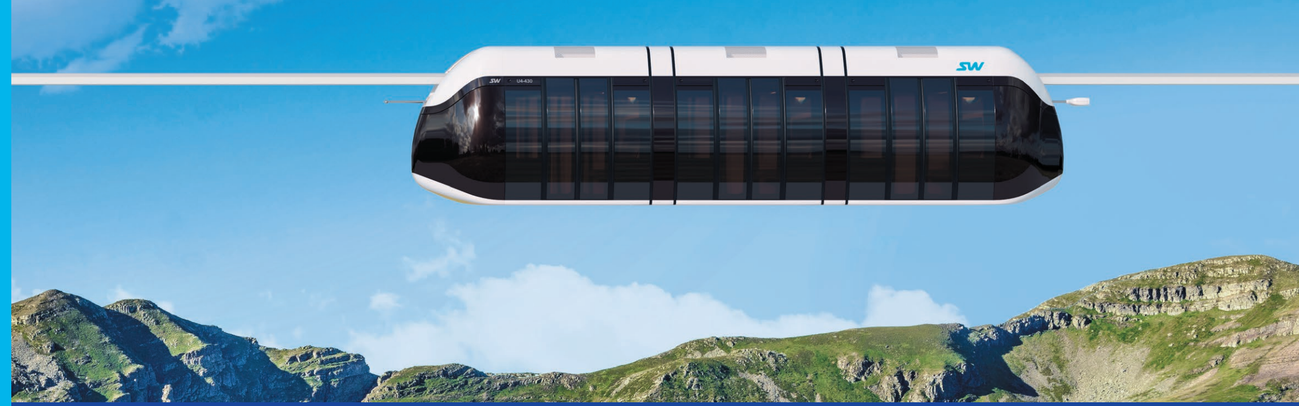
– longtitudinal commpression force in a restrained beam at rapid change of temperature:

$N_{comp} = \sigma \times A = E \times \alpha \times \Delta t \times A \leq P_{cr} = \frac{4\pi^2 EI}{L^2}$.

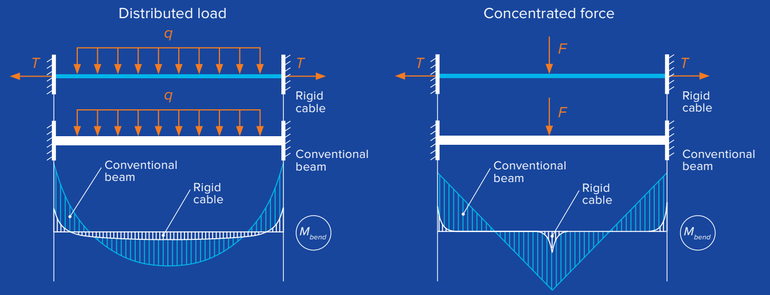
For steel,

with σ = 240 MPa and A = 100 cm²:
$N_{comp} = 240 \times 0.01 = 2.4$ MN (ca. 240 t).

With the pre-stressing force more than 2.4 MN, there will be no compression forces in the structure and it will not lose its stability.



BENDING MOMENT DIAGRAMS IN A RESTRAINED BEAM (CONVENTIONAL STRUCTURE) AND IN A PRE-STRESSED RIGID CABLE (SKYWAY)



Bending moments in a rigid cable are by 10 times lower than in a conventional beam.

CONCLUSION

The most dangerous phenomenon when heating a rigidly restrained beam is the loss of its stability.

SOLUTION

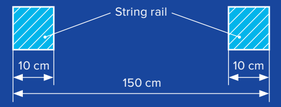
A pre-stressed beam with calculated force of $T > N_{comp}$ ensures that even temperature difference of Δt = 100°C will not cause compression forces in longitudinal fibers of the beam.

HIGH EVENNESS OF THE TRACK

is achieved due to using an uncut string rail between anchor supports

- Intermediate supports installed at a span from 25 up to 100 m (to ensure rigidity of the uncut track structure) allow using light structures.
- The amount of materials required for construction of supports can be reduced by 8 times, resulting in cost reduction by the same figure.
- An uncut structure of the string rail in its overpass design reduces the amount of building materials and their cost by 15 times and more compared to a conventional beam overpass.
- Fixing of the support top to the track structure additionally increases its load-bearing capacity by 8 times.

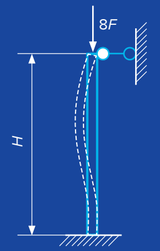
SKYWAY TRACK STRUCTURE



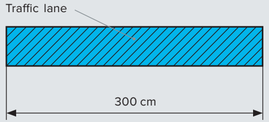
Construction cost of a SkyWay overpass –

from 10 mln USD/km.

Loss of stability in a SkyWay support



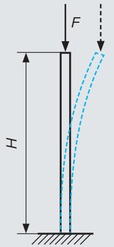
ROADBED OF CONVENTIONAL OVERPASS

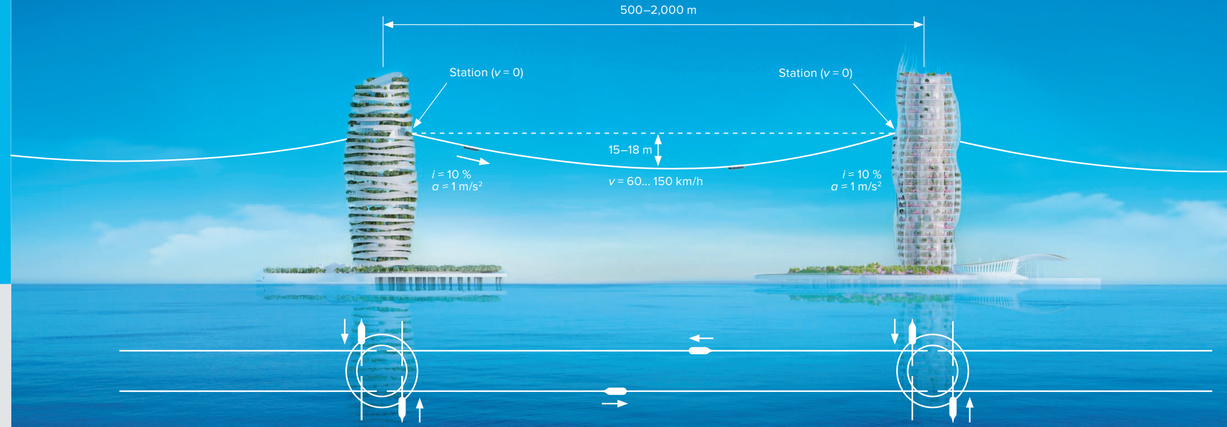


Construction cost of overpass with conventional supports –

from 100 mln USD/km.

Loss of stability in an ordinary support





APPLICATION OF **ENERGY CONSERVATION LAW** IN INNOVATIVE SKYWAY TRANSPORT

In terms of energy consumption, an overpass with a sagging track structure is by times more efficient than a road with a straight track structure.

The drive in the SkyWay transport system with a sagging track structure is only required to compensate for aerodynamic losses and to overcome steel wheels rolling resistance on a steel rail (about 10 kW for a 50-seat vehicle). It is explained by the fact that an engine is not used at a downhill section of the track – a vehicle is accelerated by gravity (gravity engine).

The unibus does not need brakes at an uphill section – it is slowed down by gravity (gravity brakes).

Energy recuperation according to the scheme "potential energy at the station ➡ kinetic energy of motion on overpass ➡ potential energy at the next station" occurs without using a recuperator in accordance with laws of physics. The efficiency of such recuperation is 100 %.

SMOOTHNESS OF MOVEMENT

Passenger comfort is estimated by the smoothness of movement *W*:

$$W = 2.7k \sqrt[10]{A^3 \times f^5},$$

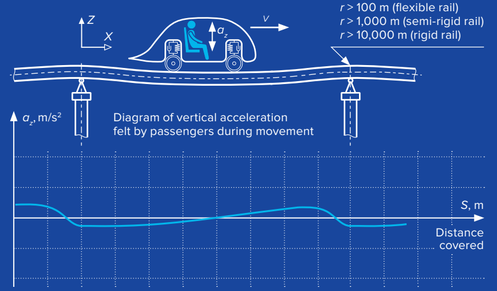
where *k* – coefficient, which depends on direction and vibration frequency;
A – oscillation amplitude, cm;
f – oscillation frequency, Hz.

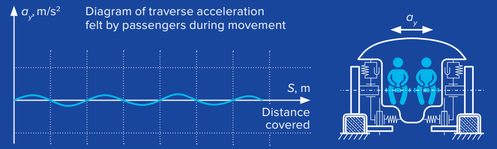
Evaluation	Index of smoothness of movement, *W*
Very good	Less than 2
Good	2–2.5
Satisfactory for passengers	2.5–3
Impermissible for passengers	3–3.25
Permissible for cargo	3.6–4.25
Unsafe for passengers from the physiological perspective	4.5

SkyWay

Automobile and rail roads

UNCUT PRE-STRESSED OVERPASS (SKYWAY TECHNOLOGY)

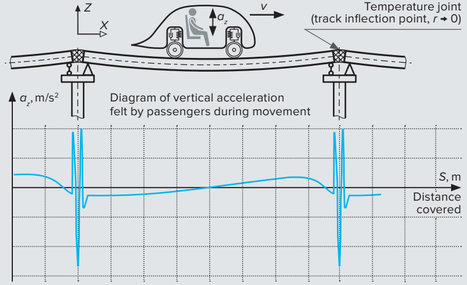


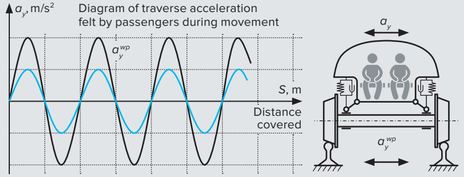


ADVANTAGES:

- smooth change of acceleration when moving through supports;
- more simple design of the supporting node.

SPLIT OVERPASS (CONVENTIONAL BRIDGE)

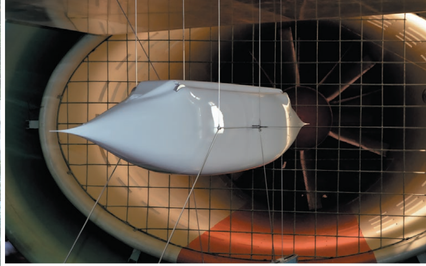




DISADVANTAGES:

- peak values of acceleration when moving through supports;
- complicated design of the supporting node with a temperature joint.

AERODYNAMICS OF A WHEELED VEHICLE



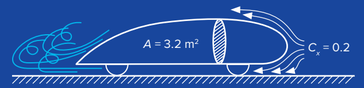
Wind tunnel test of a model of high-speed unibus (scale 1:5), 2017

The location of the track structure above the ground and the absence of a solid roadbed eliminates the main problem of high-speed transport – ground effect. This alone allows improving vehicle aerodynamics twofold.

The operation of one high-speed unibus during 25 years will allow saving about 22 tons of fuel at cost of 20 mln USD.

Thus, a thousand unibuses with unique aerodynamic properties can save over 20 mln tons of fuel, at the cost of more than 20 bln USD. At the same time, more than 70 mln tons of atmospheric oxygen would not be burned and more than 100 mln tons of pollutants would not be released into the atmosphere.

Wind tunnel tests of the innovative SkyWay rolling stock (unibus) in 1994–2009 gave the result C_x = 0.075.

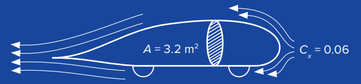


The ground effect causes turbulence.

This provides saving of drive power in one SkyWay vehicle of about 600 kW compared to the most advanced of alternative ground transport vehicles (C_x = 0.2).

As a result of wind tunnel tests carried out in 2017, C_x of the SkyWay rolling stock was improved to 0.06:

ΔC_x = 0.2 – 0.06 = 0.14.



Power saving of aerodynamic resistance (at speed of 450 km/h):

$$\Delta P_{ar} = \frac{1}{2} \rho \times v^3 \times \Delta C_x \times A \times k = \frac{1}{2} \times 1.25\ \text{kg/m}^3 \times$$

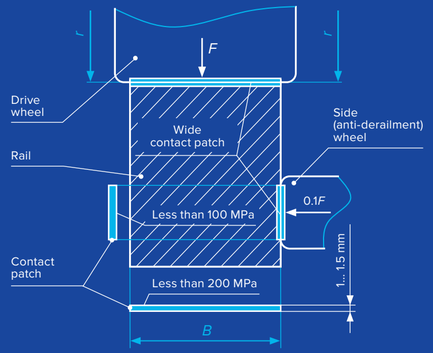
$$\times (125\ \text{m/s})^3 \times 0.14 \times 3.2\ \text{m}^2 \times 1.1 = 600\ \text{kW}.$$

ADVANTAGES OF SKYWAY STEEL WHEELS

ADVANTAGES OF SKYWAY TRANSPORT WHEELS:

- no slipping in the contact patch (cylinder rolling along the plane);
- small wheel load and absence of joints on the track;
- insignificant contact stress (less that 200 MPa) due to a wide contact patch (by rail head wheel);
- minor wheel rolling resistance due to narrow contact patch (in direction of rolling);
- symmetrical rail head wear (vertically and horizontally);
- disk brake mechanisms and ABS preventing wheels locking.

INNOVATIVE UNIBUS WHEEL



Calculation of contact stress
for a high-speed unibus with gross weight of 5 tons:

$$\sigma_c = 0.418\sqrt{\frac{F \times E}{B \times q \times r}} = 0.418\sqrt{\frac{0.0125\ \text{MN} \times 2.1 \times 10^5\ \text{MPa}}{0.08\ \text{m} \times 0.8 \times 0.26\ \text{m}}} =$$

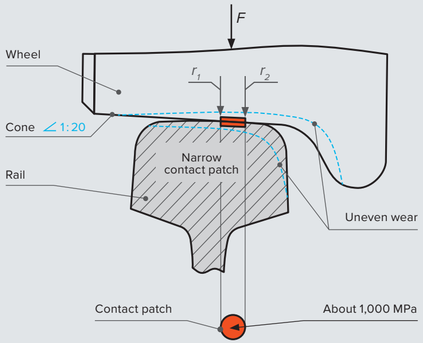
= 163 MPa (ca. 1.7 t/cm²),

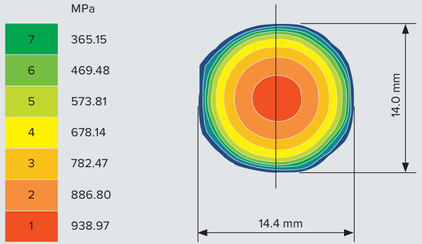
where F – wheel load;
E – effective elastic module;
B – width of wheel supporting part;
r – wheel radius;
q – coefficient of contact irregularity by length.

INCREASED WHEEL WEAR AND NOISE AS A RESULT OF:

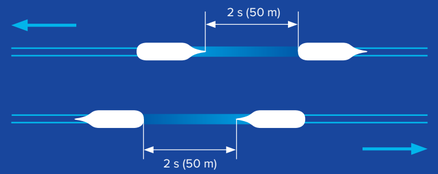
- slipping in contact patch, caused by difference of seating diameters in conical surface of the wheel;
- a rigid wheel pair prone to self oscillations, which increase wear and noise;
- big static and dynamic wheel loads combined with inevitable track irregularities;
- operation of brake mechanisms (brake shoes cause additional wear to the wheel thread);
- big contract stresses (1,000 MPa and more) caused by a small size of the contact patch;
- asymmetrical load application onto the rail head.

CONVENTIONAL RAILWAY WHEEL





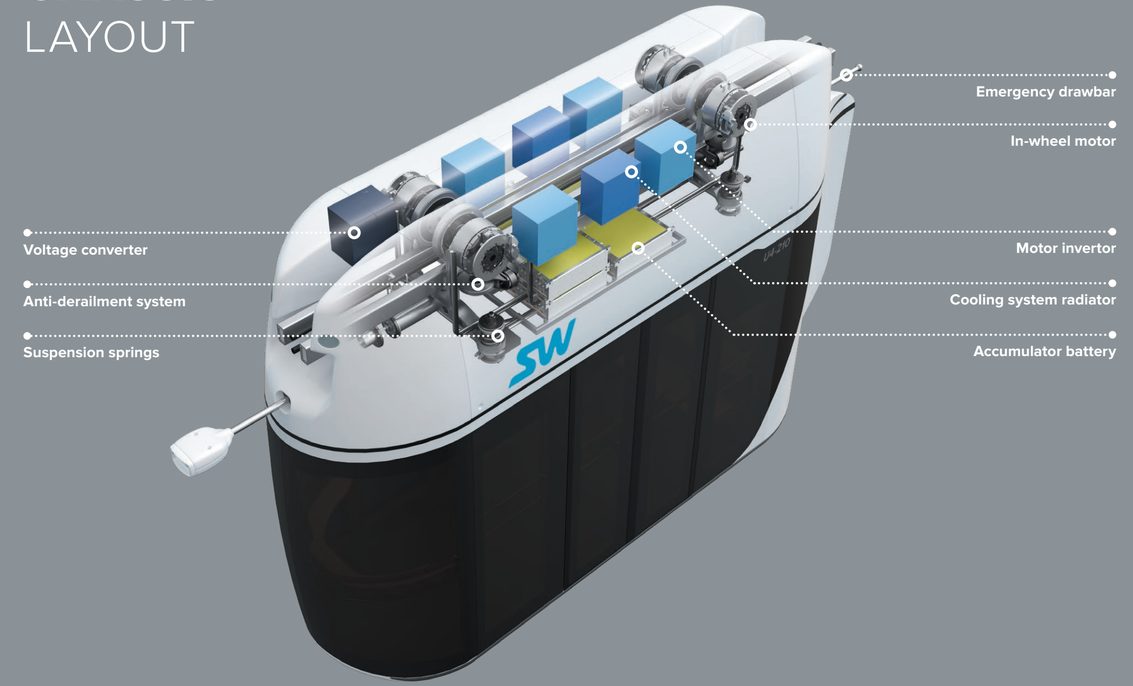
TRANSPORTATION CAPACITY
OF INNOVATIVE SKYWAY TRANSPORT SYSTEM



A safe time interval between the SkyWay transport vehicles is 2 s (or 50 m), in real life – 35 s (more than 500 m). Minimal safe interval between the transport vehicles of 2 s (50 m) is recommended by American organization Automated People Mover (APM) Standards Committee.

Maximum volume of passenger traffic will be 30,000 passengers per hour (roundtrip) for the trains consisting of seven 25-seat unibuses.

CHASSIS
LAYOUT



INTELLECTUAL CONTROL SYSTEMS OF SKYWAY TRANSPORT COMPLEX

Intellectual control systems (ICS) of the SkyWay transport complex are a well-balanced combination of the known and proved effective technologies and advanced modern technologies related to neural networks, digital intelligence, Big data, blockchain. ICS covers all aspects of functioning of the SkyWay transport complex. They collect data from all components of SkyWay and allow getting effective management solutions automatically without operator.

Implementation of ICS will increase the efficiency of traffic control, reduce non-productive costs connected with cargo and passenger transportation, and accelerate the development of the informational space on the Earth.

SAFETY
OF TRANSPORT SYSTEMS

The technogenic character of the conventional transport causes environmental disorder:

- open and ground water movements, natural habitat and migration ways of birds and animals are violated;
- many hectares of land are taken out from the beneficial use;
- noise and vibration and electro-magnetic emission, air and hydrosphere contamination increase the disease rate of the population;
- railway wrecks and accidents on oil pipelines are accompanied by emission into the environment of big volumes of chemical products.

According to statistics, the crashes and accidents annually cause death to 1.5 mln of people, millions of people become disabled.

The construction and operation of expensive and material intensive conventional transport infrastructure requires significant amounts of financial and natural resources.

SKYWAY IS THE SAFEST TRANSPORT SYSTEM

The measures preventing the SkyWay transport system from occurrence of danger are described in details in operation manuals, technical and project documentation on separate components of the complex. The design of rail-string overpass is conducted on basis of the main principles of reliability of the structures in accordance with ISO 2394 "General principles on reliability for structures, IDT".

- High resistance to vandalism and acts of terrorism.
- Location of the track structure above the ground enhances traffic safety by approx. 100 times.
- The "second level" of movement of SkyWay transport vehicles, absence of cross-roads, eliminates the possibility of traffic accidents with ground transport, pedestrians, domestic and wild animals. Minimal height to the bottom of the transportation vehicle: from the ground surface – 4.5 m; from non-accessible roof and top of buildings – 2.5 m; from the surface of the automobile roads – 6.5 m.
- Anti-derailment system increases traffic safety by another 10 times.

SAFETY OF SKYWAY TRANSPORT COMPLEX

Transport
(structural elements of safety)

1. Overpass components safety
2. Vehicle components safety
3. Safety of passengers at the station

Information
(intellectual control system)

Ecological
(eco-friendly)

TRANSPORT
COMPONENT OF SAFETY

1 OVERPASS COMPONENTS SAFETY

Durability of the rail-string overpass

The pre-stressing of a string rail by tension allows us to:

- significantly improve stress strain behaviour of the track structure, reduce the range of tension from cyclic-repeated rolling dynamic loads in order to increase durability of the structures;
- optimally compensate internal forces and deformations of the track structure caused by the thermal impact, eliminate the influence of climate factors on its durability, and eliminate buckling of the uncut string-truss overpass caused by its heating by the sun;
- effectively use high-strength materials, since the high design resistance of the string material is optimally used regardless of the geometric shape of a string section;
- eliminate formed contraction joints, increase durability and safety of the overpass.

The design solutions used for the SkyWay transport overpasses provide reliable protection for the key components from influence of the external factors (a string is hidden into the rail, the anchored assemblies are protected by the construction of anchor supports, etc.)

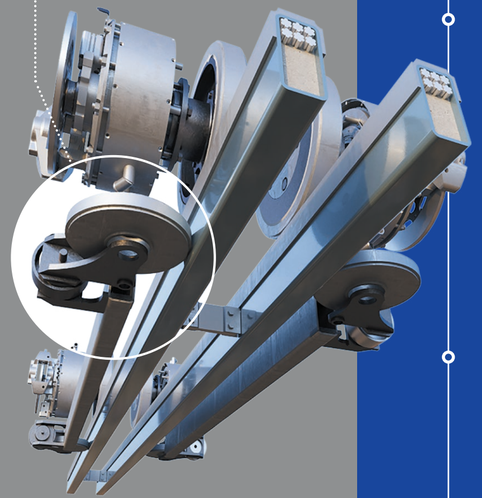
The SkyWay transport system is resistant to floods, landslides, earthquakes, seismic sea waves, and other natural disasters, as well as terrorist attacks.

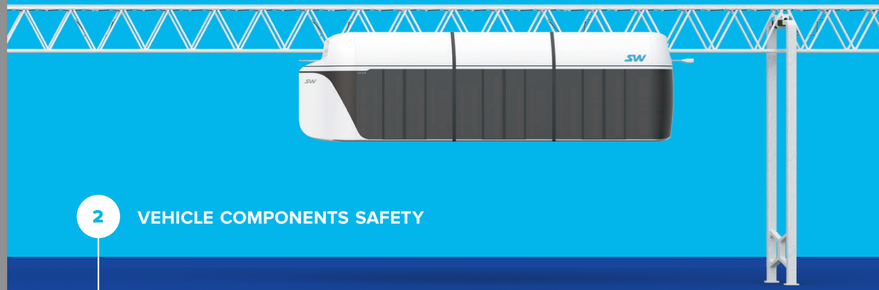
High smoothness of the track

The SkyWay transport vehicles move not along the string, but on rail, which flexural rigidity is by 1,000 and more times higher than that of the railway rail. Thus, under the vehicle wheel, the rail-string will behave not as a flexible cable, but as a rigid beam: under concentrated force of the wheel the local bending radius (bending) of rail-string will be 1 km. This means that the rolling of the wheel will be smooth, without strikes both between the supports and over support.

The continuous rail-string track, absence of contraction joints, damped design of the wheel, rail-string and concrete anchored supports makes rolling of the SkyWay transport silent at all ranges of speed and does not cause vibration to the soil.

The SkyWay electric vehicle equipped with anti-derailment system is the safest of all known transport vehicles.





2 VEHICLE COMPONENTS SAFETY

The anti-derailment system includes the following subsystems which duplicate each other:

- a subsystem of guiding side wheels with wheel safety flanges protecting from vertical separation from the rail and rolling over of the transport vehicle;
- a subsystem of retaining bottom wheels for suspended vehicles. It allows increasing stability against vertical separation from the rail and rolling over of the transport vehicle;
- a duplicating subsystem: the construction of support wheels has safety flanges;
- the vehicle framework design, which encloses the rail, eliminates the possibility of its fall from the rail track. The safety is ensured by the geometrical shape of the construction (horseshoe-shaped);
- an emergency restraining device, equipped with friction elements – "rail" brake.

The brake system of SkyWay transport vehicles has two brake circuits: main and auxiliary.

The auxiliary system provides brake force which is not less that 50 % of maximum brake force of the main brake system.

A rail parking brake can be used as an emergency brake. In case of emergency situation the transport vehicle is lowered onto the rail brake and slides on the rail, which provides slowdown.

2 VEHICLE COMPONENTS SAFETY

Safety of the electric system of the transport vehicle

- Availability of the backup batteries on the electrified tracks.
- Accumulation of electric power in order to maintain the operation of the vital functions.
- Distributed (multiple) electric drive.
- The passenger modules have the equipment with a supply voltage of 24 V.

Safe time interval between the transport vehicles

A safe time interval between the transport vehicles depends on the type of coupling (hitch or electronic) of transport modules and their capacity.

For the trains (transport vehicles consisting of a number of modules in a rigid coupling) the specified safety interval is 30–50 s; between modules on electric coupling – not less than 2 s.

Other measures for prevention and elimination of emergency situations

- Double electric isolation of the passenger module.
- Protective structures of moving parts and electrical parts.
- Use of non-flammable materials in passenger module.
- Availability of the automaticly coupling emergency and towing device.
- Availability of the coupling joints and aerodynamic fairing of the passenger module with the function of provision of the deformation zone in case of a crash.
- Individual means of evacuation for passengers.
- Duplex audio- and video communication with an operator.
- Automated fire-extinguishing system of the drive module and equipment compartments.
- Fire-extinguishers in passenger module.
- Emergency ventilation.
- Emergency exits.

3 SAFETY OF PASSENGERS AT THE STATION

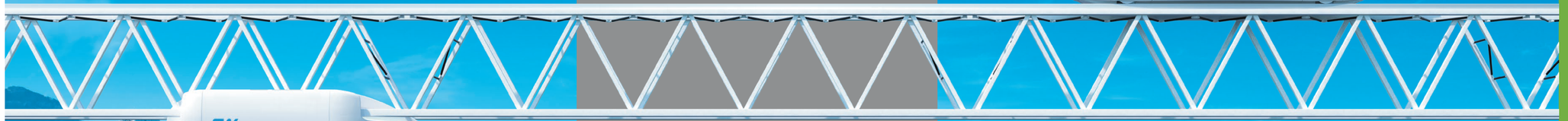
- Door opening/closing sensors
- Control system for the functional equipment
- System of optoelectronic and radioelectronic view
- Sluice doors
- Video cameras at the station

INFORMATION COMPONENT OF SAFETY

The SkyWay intellectual control system minimizes the influence of human factors, providing unprecedented safety of the whole transport complex.

Intellectual control system of transport vehicles allows us to:

- duplicate the communication system of a transport vehicle with the central control system (using two different channels);
- evaluate threats and obstacles on the way of a transport vehicle by means of technical vision and the system of sensors;
- automatically inform the central control system of any failure and emergency situation in the transport vehicle;
- automatically evaluate destructive actions of passengers in the cabin by means of technical vision and the system of sensors.



ECOLOGICAL COMPONENT OF SAFETY

The basis of the SkyWay project is the principle of careful integration into the environment of the transport and infrastructure complex of the new generation.

- The SkyWay electric vehicle in combination with high aerodynamic qualities is the most economical vehicle with minimal environmental impact.
- The SkyWay transport vehicle, using the alternative sources of energy (electric drives, batteries, energy storage devices) does not pollute the atmosphere.
- The construction of SkyWay elevated tracks preserves the natural landscape, biogeocenosis and biodiversity of the surrounding area.
- Due to the absence of embankments and excavations, there will be no obstacles to the natural movement of ground and surface waters, the movement of equipment, people and animals.
- Low volume of earthwork and small area of land used for construction of SkyWay routes will reduce to the minimum removal of fertile land (humus) from land tenure.
- Operation of SkyWay vehicles does not require the use of anti-icing salts, the chemical reactions of which produce the by-products that have negative impact not only on the environment, but also on human body.
- The track structure and supports of the SkyWay transport overpass have extremely low material consumption.

SKYWAY
AND ECOLOGY

Reduced resource consumption – saving of raw materials, land, power, labour and finances

Reduced amount of hazardous emissions into the atmosphere (by times) due to less power consumption

Preservation of natural ecosystems and geobiocenosis

Increased electrical, vibro- and noise safety (by 10 times)

Minimal local land allocation (reduced by 20 times)

No earth embankment (low head dam)

SKYWAY COMPARED TO THE EXISTING ANALOGUES

As estimated by the Russian Academy of Sciences, the innovative SkyWay transport technology is the most cost-efficient, sustainable and safe in comparison with all known and prospective transportation systems.

Maglev

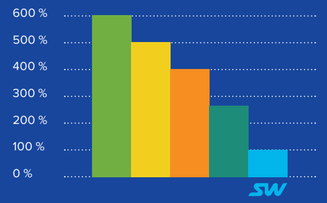
Monorail

Automobile transport

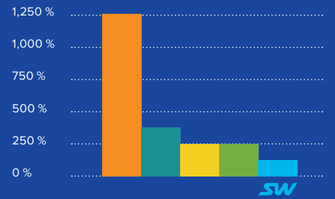
Railway transport

SkyWay string transport

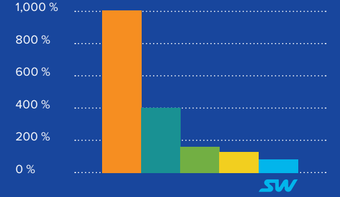
OPERATING COSTS



ENVIRONMENTAL POLLUTION



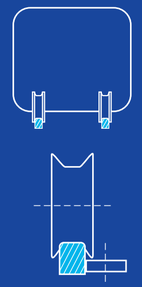
TRAFFIC ACCIDENT RATE



ADVANTAGES OF HIGH-SPEED SKYWAY

HIGH-SPEED SKYWAY

The SkyWay track structure is lighter and cheaper due to its elegant design. It does not require the installation of electric coils and provides a simple anti-derailment system.

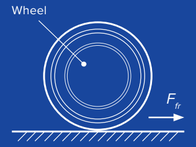


The track structure operation does not require any additional machinery as it is capable of selfcleaning (e.g. from snow and icing) and has no complicated technical elements (electric coils, etc.).

High-speed overpass cost –

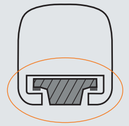
from 20 mln USD/km.

Use of steel wheel provides the efficiency factor over 99.8 %.

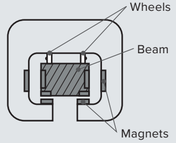


MAGLEV

The track structure operation is more labour intensive due to its complicated configuration and technical components (electric coils, switching devices, etc.), which require constant maintenance and machinery for cleaning the track from snow and icing.



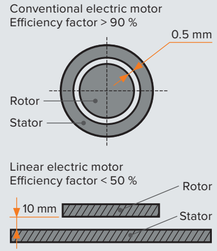
The track structure is expensive as it has a massive roadbed, it requires the installation of electric coils and a complex anti-derailment system.



Overpass cost –

from 50 mln USD/km.

The use of a linear electric motor gives the efficiency factor not more than 50 % as the clearance between a rotor and a stator (e.g. in Transrapid) cannot be less than 10 mm. However, the clearance should not exceed 0.5 mm for the effective electric motor operation.



SWIC

SWIC is the SkyWay Innovation Center in Sharjah (UAE). The research and production cluster will feature urban and cargo transport complexes of all types: mounted and suspended, monorail and double-rail, with flexible, semi-rigid and rigid track structures.

Within the framework of the SWIC project, new vehicles and infrastructure solutions will be tested: a fragment of a linear city with high-rise towers will be built, the creation of its own research laboratories and a scientific and technical base with a certification center is planned. In addition, in the future, the Center should become a part of the infrastructure of SRTIP – Sharjah Research and Technology Park.

The SkyWay Innovation Center in Sharjah will demonstrate both already tested in Belarusian EcoTechnoPark rolling stock, and the new line of rail electric vehicles for urban and cargo complexes. On the first stage among the new products – passenger four-seat unicar U4-431-01 VIP version and cargo unicont, intended for transportation of 20- and 40-foot containers. In the future, it is planned to expand the range of transport vehicles with suspended and mounted vehicles of greater loading and carrying capacity, capable to demonstrate increased freight traffic (up to 200 million tons/year) and passenger traffic (up to 50 thous. passeng./hour).

The Innovation Center will demonstrate various types of track structure and supports, not only eye-catching by their look (the aesthetics of structures is one of the main requirements), but also fundamentally improved and modernized, in terms of load-carrying capacity, material consumption and construction technology. Large spans between intermediate supports – up to 1,000 m – will also be presented in SWIC.

In addition to fully functional test sites, the creation of a full-fledged infrastructure of urban complexes, up to boarding stations, turngates and a ticketing system, is planned on the territory of SWIC.

In order to provide the possibilities for development of the network of string rails in the region and around the world, the SkyWay Innovation Center will act as a base for research and development.

American University of Sharjah, together with the Innovation Research and Technology Park, plans to establish a Competence Center, which will train specialists in design, construction and operation of string transport.

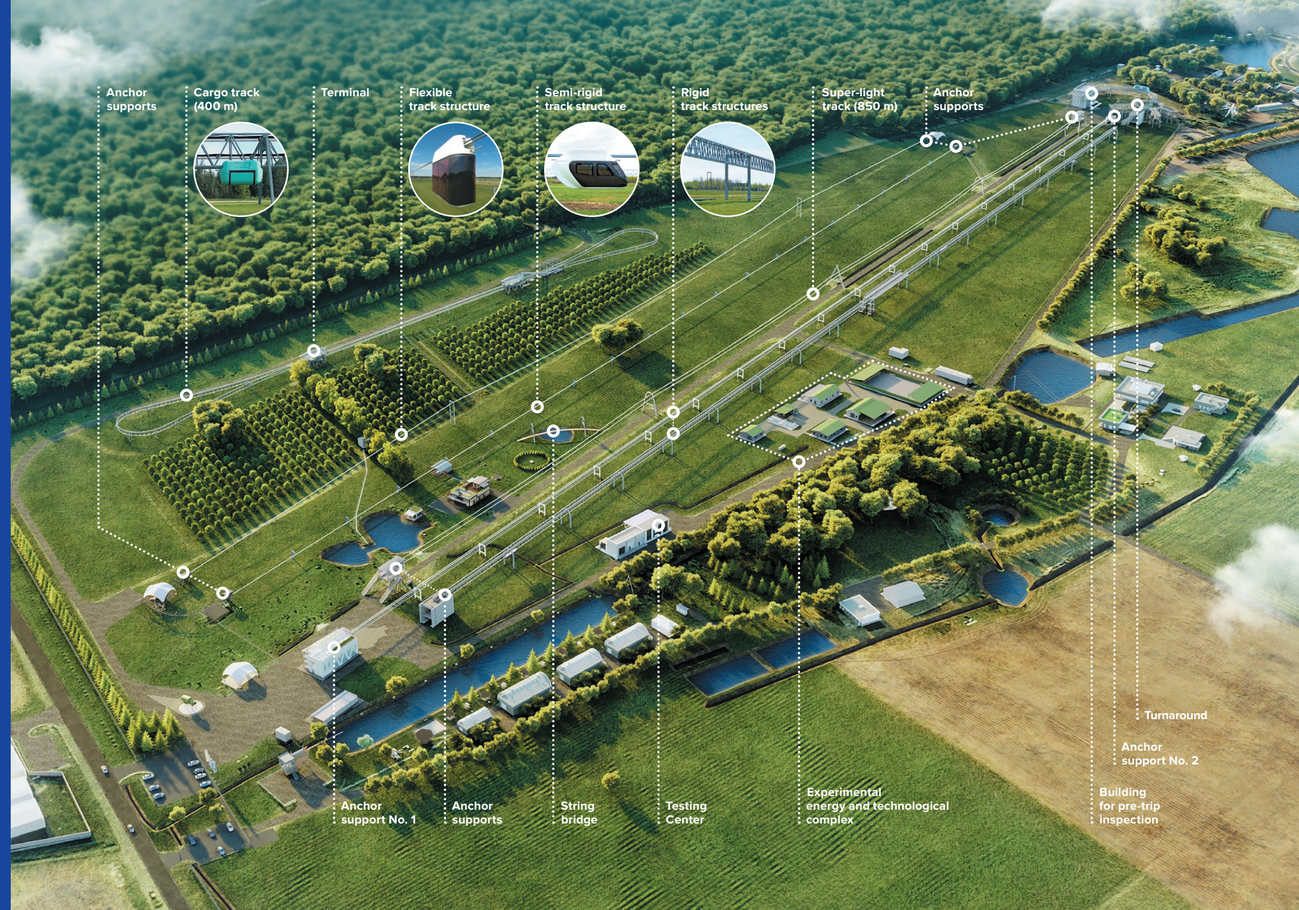
SKYWAY
ECOTECHNOPARK

EcoTechnoPark is the center for practical implementation of SkyWay innovative technologies, their international expert evaluation and certification.

EcoTechnoPark with an area of 35.9 hectares is located near Maryina Gorka (Belarus).

EcoTechnoPark:

- facilitates the certification process for every complex and their components – a transport overpass, rolling stock, infrastructure, etc.;
- contributes to the constant development and modernization of SkyWay technology;
- represents an accompanying communication infrastructure, including ecogenic bio- and agricultural technologies;
- represents current industrial models of SkyWay transport and infrastructure complexes: passenger and cargo;
- demonstrates the ecological potential of the SkyWay technology – minimal footprint for the track, reduced material and power (fuel) consumption in the course of construction and operation, etc.



SKYWAY-AGRO

Organic farming is farming with no use of chemical fertilizers, pesticides, herbicides and other toxic substances, and with application of gentle methods of soil treatment.

SkyWay-AGRO is the project which purpose is not only the organization of organic farming, but also the greening of sites along SkyWay tracks, the creation of green roofs, etc.

SOCIAL AND ECONOMIC POSSIBILITIES OF THE SKYWAY-AGRO PROJECT

Creation
of favorable living environment for people.

Preservation
of the natural balance in nature.

Provision
of rational and efficient functioning of land resources and land protection.

Development, greening and settlement
of deserts.

Restoration
of the territories suffered from human activity.

ON THE WAY TO PRESERVATION OF THE ENVIRONMENT

Humus is one of the important means for replenishment of the biological resources of our planet, it is favorable for the growth and development of plants.

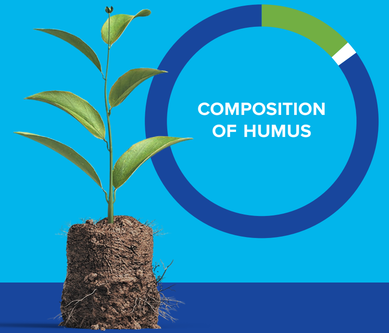
The fertility of soil depends on this unique microbiological fertilizer. It is the source of nutrients for green plants. Humus contains many macro- and microelements (nitrogen, phosphorus, potassium etc.), which after mineralization become available to plants.

Humus UniTerra is manufactured from brown coal, ash, inoculum, aerobic microorganisms and used for restoration of the fertility of the soil and improvement of the soil characteristics.

FUNDAMENTALLY NEW APPROACH TO THE USAGE OF LAND RESOURCES

Humus UniTerra was tested on the experimental land plot of SkyWay EcoTechnoPark, created on a former tank training ground.

Today EcoTechnoPark is also an illustrative example of ecological potential of SkyWay-AGRO, demonstration of the rational use of natural resources, implementation of modern agricultural ecological technologies and creation of organic farming zones.



COMPOSITION OF HUMUS

80–90 % – specific organic (humus) substances. They consist of humic acids, fulvic acids and humine.

10–15 % – organic substances of individual nature. Represented by compounds that make up plant residues. These include: proteins, amino acids, carbohydrates, fats, waxes, etc.

PURPOSES OF USING HUMUS:

- restoration of soil fertility, including depleted ones;
- growth acceleration and plant development;
- obtaining environmentally friendly crop;
- exclusion of the use of chemical fertilizers;
- natural soil detoxification;
- increase in crop yields;
- improving the taste of products;
- reduction in the cost of agricultural products;
- reduction of nitrate levels in agricultural products;
- elimination of the use of pesticides and herbicides;
- reduction of heavy metals and radionuclides in plants.

USER GUIDE FOR UNITERRA HUMUS

Humus UniTerra is a universal soil improver, as it is suitable not only for all plants, but also for various types of soil.

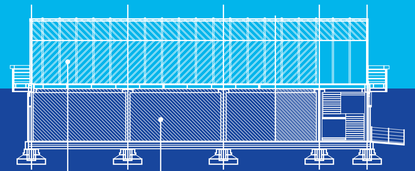
Open ground:
not less than 15–100 g of humus per 1 m² of surface depending on agroclimatic conditions and the type of cultivated plants.

Indoor ground:
not less than 0.5–2 g of humus per 1 liter of soil.

The use of UniTerra humus increases crop yields up to 20 % or more.

MODULE GREENHOUSES – FUTURE OF THE GREENHOUSE FACILITY

- Affordable
- Cost-effective
- Easy to install and use
- Universal
- Allow expanding the area of a greenhouse facility within the shortest possible time



1st FLOOR – Light-proof module. It is intended for cultivation of products under artificial lights.

2nd FLOOR – It is intended for cultivation of products under daylight with partial supplementary lighting (if required).

RAISED VEGETABLE BEDS

- Active heating by the sun
- Protection of plants from negative impact
- Reduction of the cultivated land space
- Increase in crop yield
- Reduction of labor costs
- Absence of excessive moistening and drought
- Good drainage
- Aesthetic appearance
- Individual soil for each vegetable bed

CULTIVATION OF MICROGREENS: ONE OF THE DIRECTIONS OF SKYWAY-AGRO PROJECT

Microgreens are young plants in the phase of two real leaves. It is the time when plants contain maximum concentration of the useful substances (6–40 times more that in adult plants): minerals, vitamins and bioactive compounds.

The germs are cultivated from the seeds of the following crops: lettuce, flavoring herbs, sunflower, wheat, etc.

The microgreens are cultivated on the territory of EcoTechnoPark using humus UniTerra and technology excluding the use of chemical fertilizers.

Wheat germ juice production is launched.

Microgreens is a powerful activator for immune system, natural source of proteins, fibers, antioxidants, minerals, vitamins, amino acids including irreplaceable, etc. It possesses anti-inflammatory, antibacterial, antiviral, antioxidant, wound healing, anti-sclerotic, detoxification and immunomodulatory properties.

PROSPECTS FOR IMPLEMENTATION
OF SKYWAY TECHNOLOGY

- Integration of countries into international transport corridors, creation of a fundamentally new logistics of the 21st century.
- A qualitative change in the economic structure and increase of gross domestic product (GDP) of countries.
- Maximum reduction in capital and operating costs in transport and infrastructure construction.
- The development of under-exploit and inaccessible territories, creation of a unified network of cargo, urban and high-speed intercity roads.
- The development of related industries for the production of track structure and rolling stock (metallurgy, chemical, petrochemical and radio-electronic industries, engineering, construction, etc.).

All innovative SkyWay components can be produced at project locations using the existing technological capabilities.

Track structure

Rolling stock

Infrastructure

CERTIFICATES

UNIBUS U4-210
UNIBUS U4-220

UNIBIKE U4-621
UNCAR U4-430

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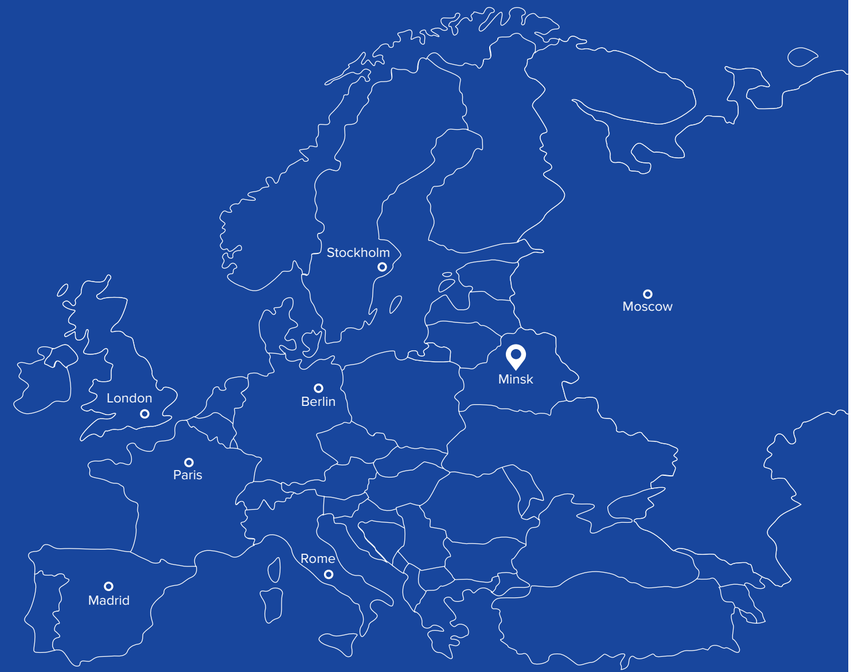

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