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Preliminary study proposal for String Coal Transportation System

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1. General Information

STU Transport System Solution

The following is a proposal for the String Transportation System (STS) based on String Transport Unitsky (STU) technology that is capable of transporting 15 million tons of coal per year over the distance of 200 kilometers. Although the cost of this system will be comparable to any other proposal that will be received, there are far more benefits than just initial capital cost. The main benefits are listed below.

Low Cost Construction

The capital cost of a STU system is lower or comparable to any other system capable of transporting 15 million tons of coal per year over 200 kilometers. Also, compared to other systems, a STU installation will have a low probability of additional costs due to unknown geology. This is due to the fact that other systems rely on stable ground for the entire length of the installation (this is especially true for conventional railroad). For these other systems, if the ground is not stable, considerable earthworks have to be undertaken to achieve stability. On the other hand STU system is assembled from pre-manufactured elements and has low dependence on terrain. The earthworks are only required for the construction of intermediate supports (every 200 meters) and anchor supports (every 2000 meters). Another important factor that contributes to the low cost of STU system is low material consumption. The weight of string-rail is only 25 kilograms per meter. The simplicity of unloading of the coal from the STU transport modules eliminates the need for traditional and costly unloading facilities.

Low Operating Cost

The main financial benefits are associated with lower operating and maintenance costs when compared with other systems. The wheel / track interface has an efficiency that is double that of traditional rail systems. Aerodynamics of transportation module has been perfected to contribute to the low energy consumption. Also the string-rail does not require extensive maintenance like a rail system track does to maintain its alignment, etc. The lowest possible energy consumption coupled with maintenance free track structure ensures the lowest possible cost of transportation.

Less Earthworks

Because the STU system is elevated, there is considerable less earthworks required.

Rapid Construction

A STU system can be constructed in 18 months, which is about half the time required for other systems.

Environmentally Friendly

The STU system is one of the most environmentally friendly systems available.
Firstly, because the STU system is elevated, there is considerable less earthworks required. This means less impact on sensitive environmental areas.
Also, the STU system is more efficient than any other system for transporting coal. This means less pollution and less greenhouse gases.
Lastly, because the STU transport modules are sealed, there is less chance of coal spillage along the transport route.

All weather operation

STU system is operational under any weather conditions including: rain, hurricane wind, storm, earthquakes etc.

Reliability

STU system is the most reliable system in existence. Its design is the result of mathematical system analysis aimed at identifying all problems that may occur and turning problems and breakdowns into regular operating conditions of the system.

2. Automatic Unicar with 7.5 ton carrying capacity for mono STU

Rolling stock (Automated Unicars) requirement

Index	Calculation	Value
Required volume of transportation — per year — per day — per hour — per second	 — (15 mil. t./year) / 300 days (50000 t/day) / 20 hrs. (2500/hour) / 3600 seconds	 15 mil. t. 50000 t. 2500 t. 0.7 t.
Carrying capacity of transportation module (Unicar)	—	7.5 t
Unicar's frequency of circulation on the route	7.5 t / (0.7 t/second)	10.7 seconds
Unicar's average speed	25 m/second	90 km/h
Average distance between two Unicars on the route	25 m/second × 10.7 seconds	267.5 meters
Quantity of Unicars required **Total Quantity of Unicars required**	200000 m × 2 / 267.5 meters	1495 5% (75) more Unicars required to replace those undergoing service/repairs **1570**

Unicar's and System's power requirement

Index	Calculation	Value
Power requirement to overcome resistance at the speed of 25 m/s – 90 km/h: — aerodynamic resistance — rolling friction resistance: — loaded Unicar (weight 11.5 t) — empty Unicar (weight 4 t)	 — — —	 2,4 kwt 2,9 kwt 1,0 kwt
Propelling power required for a loaded Unicar	1,1 × (2,4 kwt + 2,9 kwt)	5,8 kwt
Propelling power required for an unloaded Unicar	1,1 × (2,4 kwt + 1,0 kwt)	3,7 kwt
System's average energy consumption	748 × 5,8 kwt + + 748 × 3,7 kwt	7106 kwt

Description

A Unicar is an automated rail vehicle powered by 4 electric motors of 2 kwt, each motor provides propulsion for 1 of 4 separate wheels (see figures 1-4). Side derailment rollers prevent derailment under even the most unfavorable conditions. Power reserve ensures that a Unicar is operational even if one of the motors fails. Freight compartment with the volume of 5 m^3 is hermetically sealed and is closed by hatch (the hatch is opened at the loading terminal by a special lever and is closed when loading is completed) and rotary hatch at the bottom (which opens under weight of load at the unloading terminal and closes when unloading is completed) (see figures 4-8). Absence of any mechanical devices apart from the propulsion system contributes to Unicar's reliability and low cost. Unicar has perfect aerodynamic shape which contributes to its low energy consumption. Specific geometry of wheel track interface ensures the lowest possible rolling resistance. Power is supplied through contact network which is rigidly attached to the string-rail.

Figures 1-4: Unicar with protective cover removed.

Figure 5: Unicar’s rear view

Figure 6: Unicar’s front view

Figure 7: Unicar with loading hatch opened

Figure 8: Unicar with unloading hatch opened

A Unicar is a relatively simple vehicle manufactured with units and components which are certified and widely available on the market. The unique component is highly aerodynamic body. The specific shape of the body is the result of numerous wind tunnel tests.

3. Mono STU track structure

Length of span	200 m
String tension	150 ts
Weight of the string rail	25 kg/m
Deflection of the string rail under its own weight (in the middle of the 200 meters span)	0.83 m
Deflection of the string rail under loaded Unicar (11.5 t) (in the middle of the 200 meters span)	3.83 m
Maximum gradient:	5.5 %

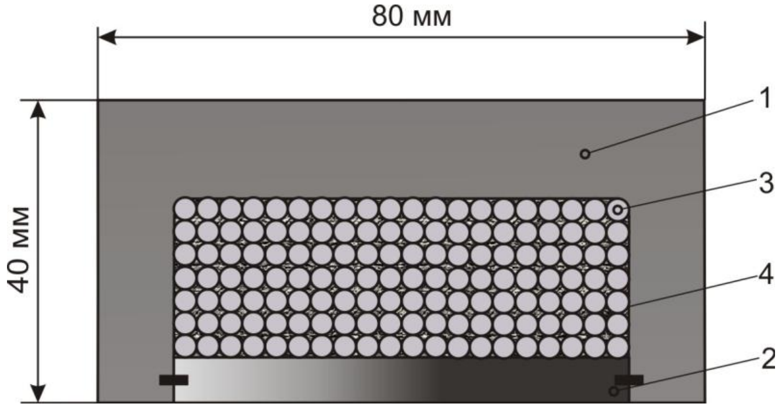
The track structure's main component is string-rails. The string-rails are reinforced with steel wires stretched/pre-stressed to 150 tons. Pre-stressed steel wires are rigidly fixed on anchor supports. The string-rails are equipped with rail head welded with no joints along the whole length of the track. The string-rail combines the qualities of a flexible thread (at a large span between the supports) and a rigid beam (at a small span under the wheel of a transportation module and above the support). This enables a wheel to roll smoothly, without shocks both in the middle of a span and above the support.

String rail is the modern interpretation of a guy bridge. It complies with all the relevant standards and specifications applied to elevated structures and far exceed them in terms of strength and structural rigidity. At the same time due to optimized building technologies, the string rail is an inexpensive structure characterized by low material consumption. String-rail requires only 25 kg of steel per meter of track structure.

STU track structure is elevated which lends number of very important advantages:

- Increased safety due to absence of the same level intersections with other modes of transport, pedestrians or animals
- Very low land requirement for track structure – approx 100 m²/kilometer
- Preservation of natural landscapes and eco systems
- Simplification of land acquisition, corridor provision and approval process
- Reduced aerodynamic resistance due to elimination of vehicle – surface interface

Cross section of Mono STU string-rail



1. Rail body (80x40 mm)
2. Bottom of the rail body (60x6 mm)
3. High strength steel wire (string)
4. Filler – special epoxy based hermetic

4. Supports

Index	Calculation	Value
Distance between supporting masts (span)	—	200 m
Distance between anchor supports	—	2000 m
Average height of a support	5 m + 2.5 m + 0.83 m + 3.83 m*	12 m
Number of supports required:		
— anchor supports	200000 m/ 2000 m + 1	101
— supporting masts	200000 m/ 200 m – 101	899

* Average height of a support determined by: minimal clearance between bottom of a Unicar and ground surface (5 m), height of a Unicar including suspension (2.5 m), deflection under the weight of the string rail (0.83 m), maximal deflection under the weight of a loaded Unicar (3.83 m).

Supports are subdivided into anchor supports and supporting masts.

Anchor supports take up horizontal load of strings and braking and acceleration horizontal strains of the rolling stock. They are installed every 2000 m depending on the length of steel wire and steel cables produced by the industry.

Supporting masts take up vertical load of strings, track structure and rolling stock as well as horizontal wind load resulting from the impact of side wind on the transportation line and the rolling stock. They are installed every 200 m and more.

Supports are made of reinforced concrete or steel welded structures and custom designed to meet specific customer's requirements.

Depending on soil peculiarities either pile (driving, screw, filling, injected) or slab (monolithic or assembled) foundations are used.

Supports could be installed in any soil—including marshlands and permafrost. The optimal method of installation will be determined during pre-project design works. This project proposal allows for the regular soil conditions.

Supports and unsplit string-rail form a rigid frame structure therefore bearing capacity of supports is increased, for example, compared with a mono-rail by 8 times (the cost of supports is accordingly reduced).

5. Loading and unloading terminals

At the loading terminal Unicars join together at the distance of 0 m and slow down to 0.5 m/sec. Loading should preferably be organized from a batcher bunker. Assuming the length of the loading zone to be 30 m, loading time will be 1 minute. Loading is facilitated automatically. If needed the loading zone can be lowered to the surface or below surface level. Unicar will than rise up to operating height using the increased gradient of first span and then will travel parallel to the ground surface (this ensures maximum energy efficiency).

At the unloading terminal Unicars join together at the distance of 0 m and slow down to 0.5 m/sec. Unloading is initiated by opening of the rotary hatch at the bottom of Unicar and can be initiated at any point required. Unloading can be facilitated into: storage area, storage bunker, railway cars, ship's compartment etc. If needed, the unloading zone can be raised to the height of up to 30 m and more.

The system can be extended offshore thus enabling unloading directly into ship's compartments. This enables to significantly reduce capital cost of the system as there is no need to build costly port facilities, which with traditional railroad can amount to 50% of the entire system's capital cost.

6. Depot

Depot for maintenance and repairs of Unicars can be located at either loading or unloading terminal or at any other point along the route. It is preferable though to locate depot at the loading/unloading terminals which for this purpose will be equipped with the switch, a Unicar requiring repair or maintenance will be diverted into depot and put back into operation immediately after maintenance/repairs completed. While repairs/maintenance is carried out, a Unicar is replaced with a spare one. The electronic system tests all units and components of a Unicar every time it's loaded and unloaded.

7. Automatic control system and control centre

Control centre can be located at any point along the route. Each Unicar is provided with automatic control system, anti collision system and GPS based positioning system, therefore exact position of every Unicar in relation to control centre, supports and other Unicars is known at all times. The transportation system is provided with multi channel, doubled communication lines with back up power generators and is fully controllable at all times under any even the most adverse conditions.

Each Unicar is provided with the simple control system, which monitors at all times: distance to the nearest Unicar (optimal 260 meters, minimal 200 meters) and speed in relation to the nearest Unicar (minimal 0 km/h, maximum 5 km/h). In case of divergence from optimal operating parameters the signal is send to electric motors to either increase or decrease drive to wheels which brings a Unicar back within optimal operating parameters.

In case of a Unicar's breakdown the next Unicar is switched into emergency mode and coupling with a failed Unicar is facilitated in manual mode by the operator. Propulsion power of a Unicar ensures that it will be able to propel its own weight as well as weight of a failed Unicar (though in the lower operating speed regime) to the depot switch, where the failed Unicar will be removed from the route for repairs and replaced immediately with a spare Unicar.

Breakdowns which will lead to complete system's failure are prevented by the design of the system and such features as:

- There is power reserve of the propulsion system therefore even if a motors fails, the remaining motors will be able to propel a Unicar to the depot for repairs;
- All systems including automatic control system are doubled;
- All Unicars undergo electronic testing of all systems and mechanisms at both loading and unloading terminals, if the testing results are not 100% satisfactory a Unicar diverted directly to depot for repairs/maintenance;
- All Unicars are electronically coupled and communicate with automatic control system, operator can in any time switch any Unicar into manual control mode if needed;

1 out of 10 Unicars is a "leader" it is provided with more sophisticated control system, on-board computer and software which allows it to control the other 9 Unicars. Therefore 10 Unicars form an electronically coupled "train" with the carrying capacity of 75 tons. If needed "leader" can interfere into any Unicar's command system to ensure it operates within optimal parameters. Length of this "electronic train" is 2.6 kilometers. All Unicars are provided with communication system, every second information is exchanged between: Unicars with each other, Unicars with their "leader", Unicars with supports, Unicars with control centre. The only transportation system provided with such a comprehensive control system is Japanese Shinkansen Bullet Trains. These trains are the world's benchmark for safety and reliability and so far have transported more than 10 billion passengers without a single fatality.

8. Safety

Each Unicar is provided with anti derailment rollers which contact with the sides of the string rail and make derailment impossible in principle. Even if an attempt is made to forcefully derail a Unicar it will not succeed because the pulling force must be sufficient to brake anti derailment rollers (10 ton +). Collision between Unicars is impossible due to automatic control system and anti collision system which operates independently of automatic control system. Coupling of Unicars can only be facilitated in manual mode by the operator.

String rail has 10 fold strength factor, in order for it to break 10 times the designed load must be applied in the middle of the span (i.e. 115 ton instead of 11.5 ton). Even if such load is applied this will not break the string rail, because in order to brake deflection must surpass 30 meters which is more than the heights of supports, therefore the string rail will expand until it reaches the ground and once the load is removed return to its normal operating parameters.

Small size of the string rail (80x40 mm) and its armored body makes it a very difficult task to destroy it with conventional firearms (i.e. rifles, machine guns etc.) while more powerful weapons don’t have accuracy needed to hit the string rail (e.g. artillery guns, grenade launchers). In fact the only reliable method of putting an STU route out of operation is to destroy an anchor support (which requires 10 kilograms of plastic explosive equivalent and professional installation).

In case the string rail is destroyed, 2 kilometer span between anchor supports can be replaced within days.

9. Capital cost of the STU system

№	Index	Millions $USD
1.	Pre project works. Optimization of technical-engineering solutions for specific transportation task. Identification of systems components and operating regimes in relation to specific conditions.	2.9
2.	Project design works. Design of: Unicar, automatic control system, loading and unloading terminals, depot, technological equipment. Preparation of complete project documentation and terms of reference. Construction of first span (2 kilometers) for testing of Unicar and other systems.	21
3.	Geo technical and route planning works. Planning of supports and infrastructure locations.	8
4.	Construction of double-track freight mono STU,	175.9
	including:	
	— double track string rail (200 kilometers)	90
	— supporting masts with the height of 12 meters (899)	40.45
	— anchor supports with the height of 12 meters (101)	45.45
5.	Construction of infrastructure,	72
	including:	
	— loading terminal	12
	— unloading terminal	14
	— depot	10
	— control center and automatic control system (including communication system)	36
6.	Rolling stock. 1570 fully automatic Unicars with the 7.5 ton carrying capacity	94.2
7.	Electrification of the system. Contact network and its components.	46
8.	Contingency 5%	21
	Total capital cost of the system	**441**

Total cost of the fully complete "turn key" system is $441 million or $2.2 million per kilometre. This compares very favourably to cost of conventional railroad and associated port facilities. For instance, Fortescue Metals Group has spent in excess of $3 billion to construct 300 kilometres rail line and associated port facilities.

10. Running costs

№	Index	Millions $USD/year
1.	Depreciation over 25 years	17.64
2.	Payroll (50 employees × 3 shifts × 30 000 USD/year)	4.5
3.	Energy cost 42636000 kwt/h x $0.1 per kwt/h	4.264
4.	Other (spare parts etc.)	3
5.	Royalty for intellectual property 1% of capital cost	4.41
	Total	**30.81**

11. Transportation costs

Cost of transporting 15 million tons of coal per year over 200 kilometers is:
($30.81 mln. USD/year) / (15 mln. t/year) = **$2.05 USD/t.**

12. Summary

Use of mono STU freight system for transporting 15 million tons of coal per year over 200 kilometers is the most efficient solution for this specific transportation task. While competing systems may have similar capital cost, none can be compared in terms of transportation costs achieved mainly due to low maintenance cost and outstanding energy efficiency of STU system.

Number of assumptions were taken as "the worst case" scenario. We offer to conduct feasibility study which will provide more precise capital cost of the system.

Cost of feasibility study is USD $0.65 million. The feasibility study will be completed in 5 months. Upon completion the prospective purchaser will receive:

1. Project design for string track structure, including:
   - calculations for structural strength and rigidity,
   - cost of required materials,
   - static and dynamic analysis;
2. Project design for coal transportation vehicle;
3. Detailed and itemized quote for specific transportation task solution;
4. Movie – computer graphics;
5. Operational scale model (scale1:10).

The outcome of the feasibility study will provide sufficient documentation for a prospective purchaser to determine beyond any reasonable doubt the system's technical soundness and high efficiency. We expect that the technical documentation will be subjected to an expertise by an independent party. Upon completion of the feasibility study and its expertise, the prospective purchaser will be well positioned to proceed to the next stage of the pre project works. We guarantee the system to be fully constructed, operational and "bugged out" in 18 months after commencement of construction.