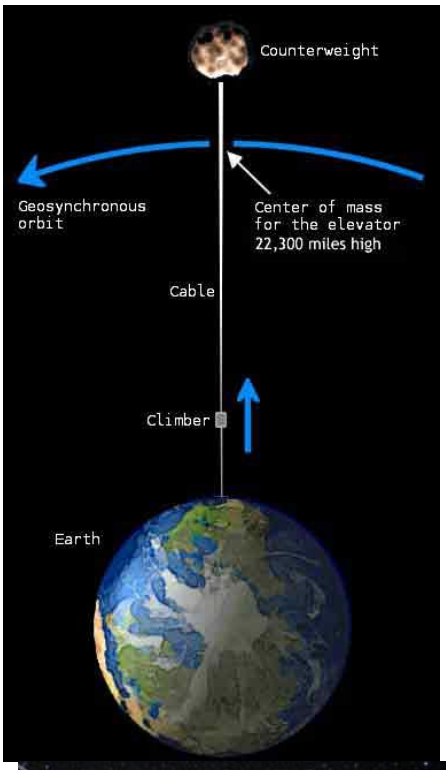
The project of the orbital elevator based on the ISS.

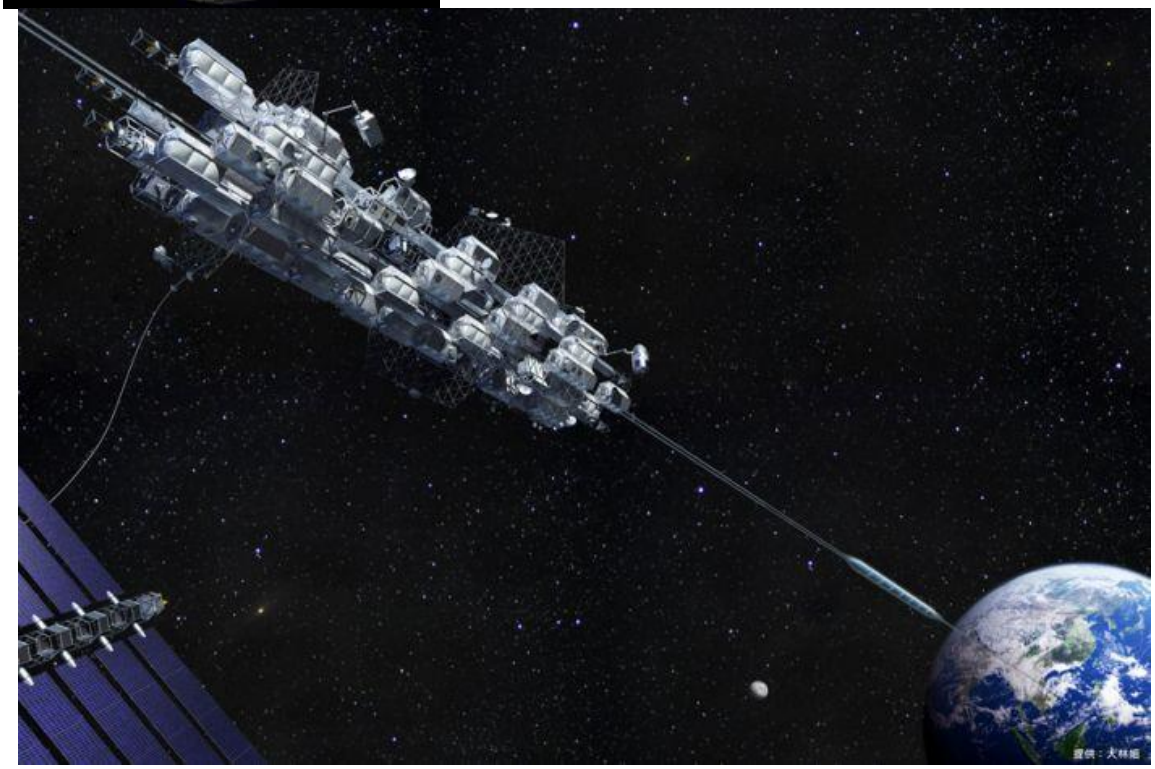
«The Agapov Orbital Lift», a project of a simplified version of the space elevator, whose cable is suspended from the ISS, flying in an orbit at an altitude of about 1.5 to 3 thousand kilometers, reaching its end to a low, near-earth orbit. This version of the space elevator is not the most efficient, but relatively stable and cheap to implement. The cable of the orbital elevator can be made of available materials, such as Kevlar or carbon fiber. Orbital elevator, can not completely replace the missiles, but can increase their capacity by 30 - 50% or more. In the future, due to gradual modernization, the orbital elevator can be transformed into a stationary elevator capable of lifting cargo into space from the ground.

The project of an orbital elevator is an accessible component of the space transport infrastructure of the future. Which can be realized when the life of the ISS ends.

The concept of a stationary space elevator.

The space elevator is considered one of the most promising components of the future space transportation infrastructure. Since this is a mechanical means of delivery of goods into space, allowing you to completely abandon the expensive missiles.





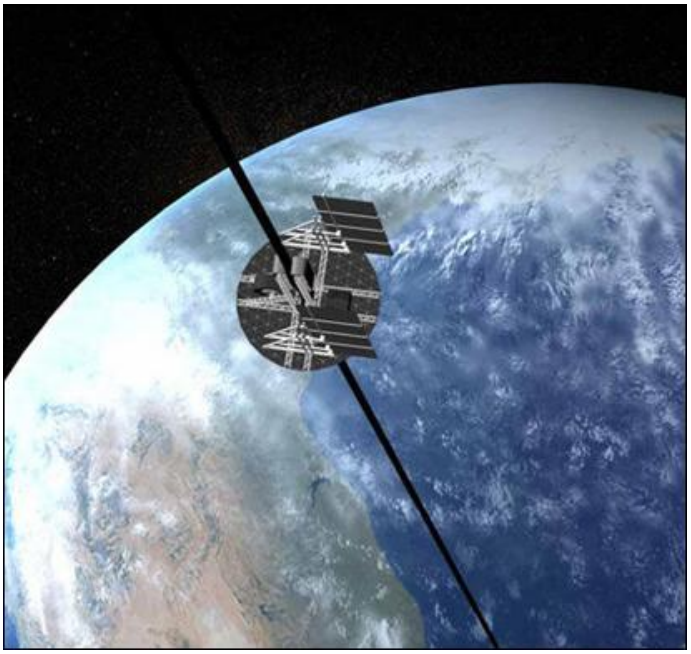
According to the principle of a space elevator, it is a long cable suspended from a massive counterweight located in a geostationary orbit, the speed of rotation on which coincides with the speed of rotation of the earth. Therefore, satellites in the geostationary orbit, "Hang" is

fixed relative to the earth's surface. And, theoretically, you can stretch a long cable between a massive load, "Hanging", just above the geostationary orbit, and the earth's surface.

Such a fixed cable leading to a geostationary orbit can serve as a simple and cheap means of cargo delivery into space. Lifting loads into orbit along a cable can be completely mechanical. To do this, do not need jet engines. No need for rockets that cost a lot of money and burn fuel 30 times more than the payload they take out.

Disadvantages of the space elevator concept.

But ... the stationary space elevator has its drawbacks, because of which it can not be translated into reality at the modern level of technology. Such as:



High load on the cable. The main drawback of the space elevator is the extremely heavy load that the fixed cable should experience. The height of the geostationary orbit, a little less than 36 thousand kilometers (35 786 kilometers), if you make a cable so long, not one of the known materials will not sustain its weight. Now there is an experimental material, durable enough to make a cable of the space elevator - “Carbon nanotubes”. But carbon nanotubes, the material is very difficult to manufacture and expensive. Now, managed to get a nanotube, only a few centimeters long. And ideally, you need about 40 thousand kilometers. To make a cable of the space elevator at the modern level of technology is almost impossible.

Vulnerability to meteor dust and space debris. The second drawback of the space elevator is its vulnerability to asteroid dust and space debris. In space, flies a lot of sand and dust, small remnants of asteroids or comets. Asteroid dust constantly bombards any space object, like a scattered flow of micrometeorites, and slowly destroys it. Satellites and orbital stations protect meteor dust with screens made of thin metal or thick foil. Meteor particles are broken on the screens, not reaching the hull plating. But weather screens are too heavy for long elevator cables.

Some protection for the cables can be given if they are made in the form of narrow bands. In this case, the hit of meteor particles will not be able to immediately interrupt the cable, and numerous hits in the tape weaken it over time, but do not tear it immediately. According to experts, the cable in the form of a tape, on average, can work in open space for about 5 years. Then it will be broken by meteoric dust, and weakened. Broken cable will not withstand heavy loads. And in five years, such a giant structure as a stationary space elevator does not have time to pay for itself. To the threat of meteor dust in earth orbit, the mass of small fragments of rockets and satellites is still added. Space debris. Which is much more destructive than meteor dust, since its large particles can immediately tear the elevator cable.

High complexity and cost of implementation. The third drawback of stationary elevators is their high price and complexity. By the cost and complexity of construction, classical, stationary, space elevators, these are mega projects. Even if it is possible to solve problems with materials for cables, and the threat of meteor dust, space elevator projects will have a huge cost, and will pay for themselves for decades. And therefore for investors they are inaccessible and not attractive.

The concept of an orbital space elevator.

The orbital space elevator is a cable stretched from a high orbit to a low one. The end of which does not reach the ground. And it hangs at a height of low orbit, about 200 - 400 kilometers from the ground. It rotates around the earth at a speed of 10–30%, lower than the orbital speed, approximately 7–6 kilometers per second, depending on the height of the counterweight. Orbital speed in low orbit - 8 kilometers per second. A heavy orbital station can serve as a counterweight to the orbital elevator. And it is also possible, a light asteroid, transferred to Earth orbit. Or lunar soil, delivered to Earth's orbit by cheap, promising vehicles.

The approximate length of the orbital space elevator rope can be from 1500 to 3000 kilometers. With such a length, the speed of the lower end of the cable will decrease by 700 -

1200 meters per second, relative to the orbital one. The cable will work in conditions of reduced gravity, which, approximately, will vary from moon to Martian. From one sixth to one third of the earth's gravity. With such a length of cable and its working conditions, modern materials of high strength can withstand their weight and a small additional load. For the manufacture of cables orbital elevators, can be used Kevlar, carbon fiber, polyethylene with a high length of molecules, comparable in strength with Kevlar. Or similar materials.

Missiles delivering cargoes to the end of the orbital lift cable will pick up speed not enough to go into a circular orbit. To enter the so-called "Suborbital trajectory", for which fuel is needed less than to go into orbit. The lower the speed of the suborbital trajectory, the more rockets will be able to carry the payload on board, with the same starting mass.

The weight of the cable orbital elevator can be tens of tons.

The ISS can serve as a counterweight to the elevator, after its service life has expired, and the station can become a dead load. The weight of the ISS is about 420 tons. Launching such a mass of material into orbit cost a lot of money, and it would be unwise to burn the station in the atmosphere after it has completed its life. But if you use the station as a counterweight to the elevator, it will continue its work as part of a new space vehicle and will be able to bring benefits in the future.

To enhance the electrical power of the ISS, it can be equipped with several additional "Generation modules." With light, thin-film solar panels of a large area, with a total capacity of tens of megawatts. Their energy can be used to power a powerful electric jet engine. This type of engines have low thrust and high energy consumption, but consumes little fuel, 5 - 30 times less than traditional rocket engines for chemical fuel. An electrojet engine will lift the station to a high orbit without spending a lot of fuel on it. And during the operation of the elevator, it will slowly but constantly accelerate the station, compensating for the decrease in its speed after lifting loads.

During operation of the space elevator, cargo delivered by rockets will cling to the lower end of the cable, which has a relatively low speed. And climb the cable on the transport modules, "trolleys", driven by electric motors. After climbing to the ISS, the cargo will acquire orbital speed. After that, they can be transferred to the desired orbit, either by traditional rocket engines, or prospective orbital tugs, on electrojet engines.

The orbital elevator, it can raise the payload of rockets by 30-50%, which is comparatively not much. But putting each ton into orbit costs at least $ 3–5 million. For the year, with the help of an elevator, 50 - 300 tons of cargo at a reduced cost can be put into orbit.

The price of the orbital elevator can range from 100 - 500 million dollars. And he can pay for himself in 3 - 5 years of operation. It cannot be called super efficient or super profitable. But the creation of such a component of the orbital transport infrastructure is available in terms of technology and costs. And the implementation of the project of the orbital elevator can be one of the first steps in the development of qualitatively new means of space transport.

One of the advantages of the orbital elevator is the ability to change the cables and the height of the station during operation. So, the orbital elevator can be repeatedly upgraded. Putting more durable and long cables, and increasing the station orbit, in the process of its work. The project of the orbital elevator, you can start with the most simple and inexpensive modification, with a cable length of about 1500 kilometers. And further, as experience is developed and new, heavy-duty materials for a cable are developed, increase the cable length to 3–4 thousand kilometers.

If it is possible to master composites made of heavy-duty polymers and carbon nanotubes in mass production, the elevator height can be increased to 5-7 kilometers and above. If with the help of an elevator it is possible to reduce the speed of carriers by 30 - 70% of the orbital speed. It will become highly effective from an economic point of view, since the delivery of goods to the cable will be carried out by inexpensive and reusable "Suborbital rockets". Similar to the modern reusable first and second stages of the Falcon missiles manufactured by Space-X. Having a low start up cost. The effectiveness of missiles will increase by 3 - 7 times.

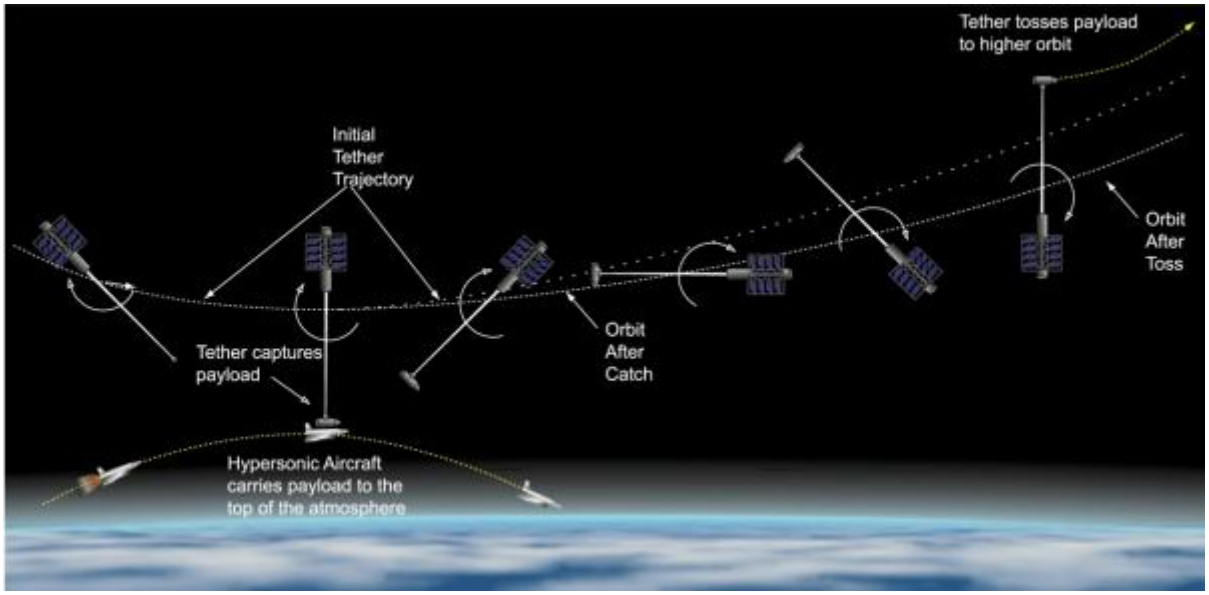
Due to the possibility of gradual modernization, the project of the orbital elevator can gradually increase its efficiency. And in the end, can be transformed into a stationary space elevator.

Thus, the project of the orbital elevator is one of the directions of transition to a qualitatively new space transport infrastructure. Available for practical implementation and profitable from an economic point of view.

Orbital elevator, working in conjunction with the orbital sling.

The efficiency of the orbital elevator can be improved if another promising means of space transport, the Orbital Sling, is placed at the end of its cable.

According to the principle of an orbital sling, it is a counterweight with a cable rotating around it. Long from one to several tens of kilometers. The end of the cable orbital sling has its own speed. Modern materials can withstand the speed of rotation of the cable slings about 1 - 3 kilometers per second at the end.



The speed at the end of the rotating cable can be either less or more than the speed of the sling itself, depending on the position in space. For example, the sling can pick up cargo from the "Suborbital flight", having a speed below the space. After that, the load, climbing the cable, can accelerate to orbital speed.

Or vice versa. A sling, located in a near-earth orbit, can give the cargo additional speed, bringing it to the flight path to the moon.

The orbital sling, as well as the elevator, is considered one of the most promising means of space transport of the new generation. Since it makes it possible to pick up cargo from a suborbital flight, bringing them into orbit of the earth. Either transfer cargo to the moon orbit, or take cargo flying from lunar orbit to earth. Without spending a lot of fuel on it.

If at the end of the cable of the orbital elevator, place a small orbital sling, this will give the elevator additional efficiency. Reduce the speed of cargo lifted by an elevator from a suborbital

flight by 1 - 3 kilometers per second. And accordingly, it will additionally reduce the cost of breeding 2 - 4 times.

The disadvantage of such a complex system consisting of an orbital elevator with a sling at the end, is that it will not be able to take heavy loads from a suborbital flight. Approximate weight of a sling, several tons. It will take with its weight the reserve of the strength of the orbital lift cable. And at the same time, she will be able to take only light loads, weighing from several dozen to several hundred kilograms. Therefore, a complex of orbital elevator and sling, will be able to take only light loads. The total capacity of the complex slingshot and elevator will be the same as that of the elevator, only it will take loads in small portions.

Instead of a single cargo weighing several tons, delivered to the end of the cable heavy rocket. A sling located at the end of the cable will receive a multitude of light loads delivered by light rockets or shuttles.

Delivering a suborbital flight payload for the elevator complex and sling, can group specialized lightweight missiles. Or a group of reusable suborbital shuttles, rocket planes.

The complex of the elevator and sling, can put into orbit the details of satellites or other spacecraft for their subsequent installation at orbital stations. And loads for which dimensions do not matter, such as fuel, or other consumables.

Space station for the extraction of fuel from the atmosphere on the basis of the orbital elevator.

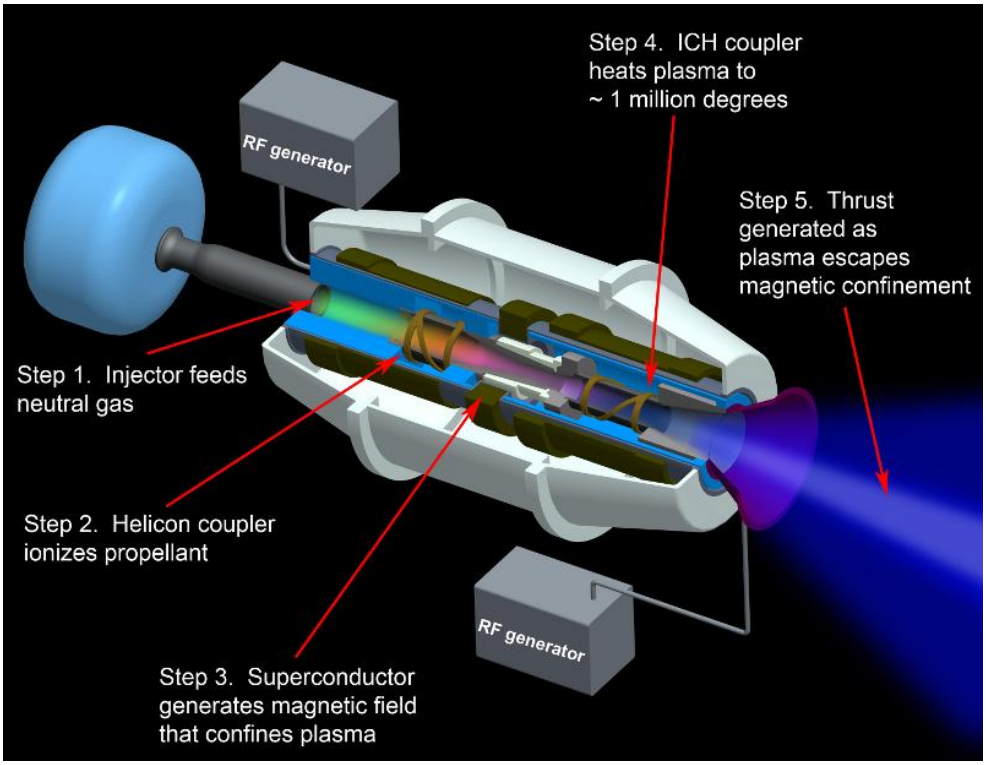
The orbital elevator has another feature. The end of its cable can be lowered into the upper atmosphere. Where with the help of a special intake device it is possible to gradually collect rarefied air. And then lift the liquefied air cylinders along the cable on the ISS. Or immediately, in the intake device, to convert the main part of air into nitrogen tetroxide, the oxidizing component of rocket fuel with a low liquefaction temperature. It can be stored in cylinders without cooling, under normal conditions.

The retarding action of the intake, and the ascent of air to the station, should be compensated for by a powerful electrojet engine on the ISS.

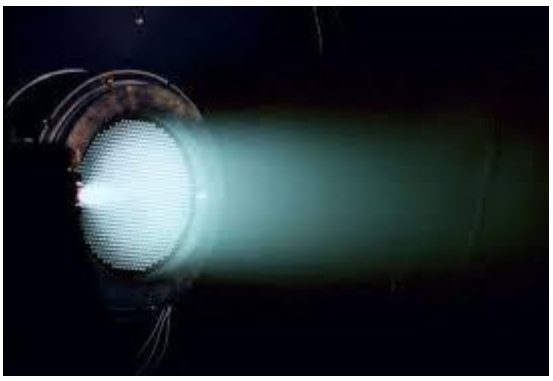
Liquefied air or nitrogenous teraoxide at the orbital station can be used as an oxidizing agent for a chemical rocket fuel. Or as fuel - the working fluid for electrojet engines.

In a chemical rocket fuel, a pair of fuel is an oxidizer, the oxidizer takes up the bulk, its weight is 3 - 8 times more than that of fuel. Therefore, the presence of an oxidizer in orbit makes it possible to repeatedly reduce the total weight of chemical fuel delivered to the station.

Air, nitrogen, or nitrogen tetroxide can be used as the working medium of electrojet engines. Especially not fastidious to the properties of fuel "Plasma engines".



Electrojet engines have a different principle of operation. The fuel in them is heated and accelerated by electric current. The fuel itself does not burn, it is a neutral substance, so its chemical properties do not matter much. In plasma engines, the fuel — the working fluid is heated to the state of a plasma, an electrically conducting gas, and is held by a magnetic field, isolated from the walls of the engine. Therefore, plasma engines can operate on an oxidizing agent, without the risk of burning.



Ion engines are more sensitive to the chemical properties of the fuel. In them, the atoms of the working fluid receive an electric charge and are accelerated in an electric field. Oxygen or nitrogen oxides are dangerous for ion engines and can burn electrodes. But ion engines can run on nitrogen.

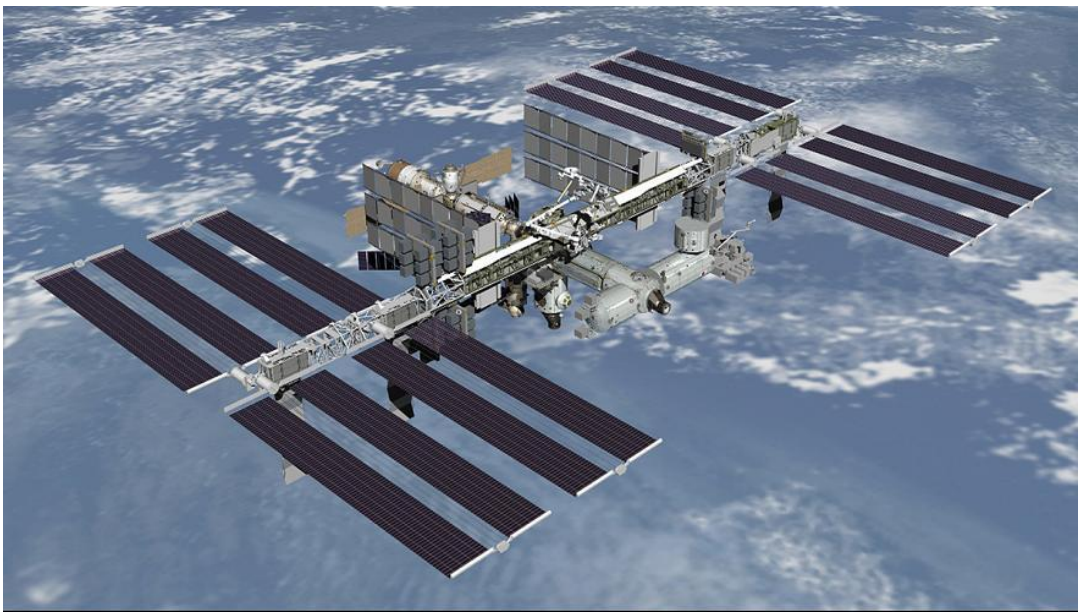
At the station, the elevator counterweight, it is also possible to use thermal engines. Powered by solar energy, concentrated by concave, film mirrors. And consuming as fuel - working fluid, hydrogen delivered from the ground. Hydrogen, thermal engines, give a jet outflow rate of two to three times more chemical. They are less economical than electrojet, but much more powerful. Thermal engines can be used as auxiliary, during periods of enhanced lift operation.

If in space to take air from the upper atmosphere, its launching into orbit will be very cheap, almost free.

The orbital elevator with the intake at the end of the cable can serve as a source of cheap fuel for the orbital group. By reducing the cost of space transport and any space activity.

From the orbital laboratory to the new space infrastructure.

The concept of creating an orbital elevator, possibly from the functions of extracting fuel from the atmosphere, based on the ISS, is one of the directions for creating a qualitatively new space transportation infrastructure. Using the currently operating orbital station.



The ISS was created as the largest scientific station for space research, a period of state, scientific demonstration cosmonautics. And with the beginning of private astronautics, focused on the practical development and industrial colonization of space, the ISS can get a second life, as part of a new space infrastructure.

The project of creating an orbital elevator based on the ISS, thanks to its flexibility, can serve as a transitional bridge from modern astronautics to qualitatively new stages of space exploration.

Conversion of the ISS to the orbital elevator, you need to start while the station is still operating as a scientific one. Lead the development of cable and electric propulsion system. Increase the weight of the station, accumulating debris on it, tanks of old missiles and other unnecessary things. Which will not interfere with the station, but will make it harder, increasing its effectiveness as a counterweight to the elevator.

There are two potential directions for the use of the ISS as part of an industrial orbital grouping of the future. First, leave the station in low orbit, turning it into a transport center for missiles and orbital tugs. And the base for satellite maintenance and production development. Three times to make on its basis the orbital elevator. Both of these areas are needed and each of them has its advantages.

If Space X, in the next decade will switch to mass production of super-heavy missiles. From empty tanks of these rockets it is possible to build a new station serving as an industrial center. Its spacious modules will be more convenient as workshops. In this case, the old ISS can be redone in opposition to the orbital elevator without regrets.

On the ISS, after transforming it into an elevator, you can conduct scientific and practical activities through remote-controlled robots and body presence suits. The elevator counterweight will go beyond the lower magnetic belts, so it will be dangerous to keep people there for a long time, due to increased radiation. So the role of the scientific laboratory and one of the centers of the space industry for the ISS as part of the elevator will be preserved, only robots will replace humans.

To start the transformation of the ISS, in contrast to the orbital elevator should be in the near future. And first of all, to lead the popularization and promotion of the idea of such a transformation.

I am a non-system supporter of the colonization of space, “Nikolay Agapov”, the author of the concept of an orbital elevator based on the ISS, and called the project by its name - “Orbital elevator of Agapov”. I am submitting the project to the British coordination center for space colonization preparation - DarkStar Aerospace. And I myself will work on the project as part of DarkStar Aerospace, attracting the attention of the general public, other private space players and industrial participants.

The first publication in the Russian popular science site «GlobalScience.ru»:
http://globalscience.ru/article/read/28150/

Nikolay Agapov.