METHOD FOR DELIVERING CARGOES INTO SPACE AND A SYSTEM FOR IMPLEMENTATION OF SAME

Patent for invention RU2398717
(PCT/RU2010/000036 Pub. No.: WO/2010/08286)

The invention described below in several detalized variants makes space transportation more effective and inexpensive by using simple technics. Analogues of this invention are the container space craft of atmospheric air PROFAC of Sterge Dimitriadis and the container space craft of solid materials (CSC) of Edward Marwick.

Essence:

The subject of this invention is the system and the method for delivering raw materials and other simple substances to orbital stations and fuel depositories.

Unique advantages:

a) makes it possible – using an orbital container device with thrusters - to increase cargo-capacity of modern space rockets up to 10-20 times;
b) makes it possible at substantially low cost (~$100/kg) to accumulate in space big stocks of raw materials to provide thermochemical rockets with fuel, space electrorocket engines (ERE) with working substance, orbital stations and space crafts with materials of anti-radiational and anti-meteoritic protection, landers with thermal protection materials, building of big space constructions out of elements created straight in the orbit, as well as for provision of orbital factories with silicon and other raw materials for production of solar batteries of space power stations of industrial scale.

The invention can be realized in different variants:

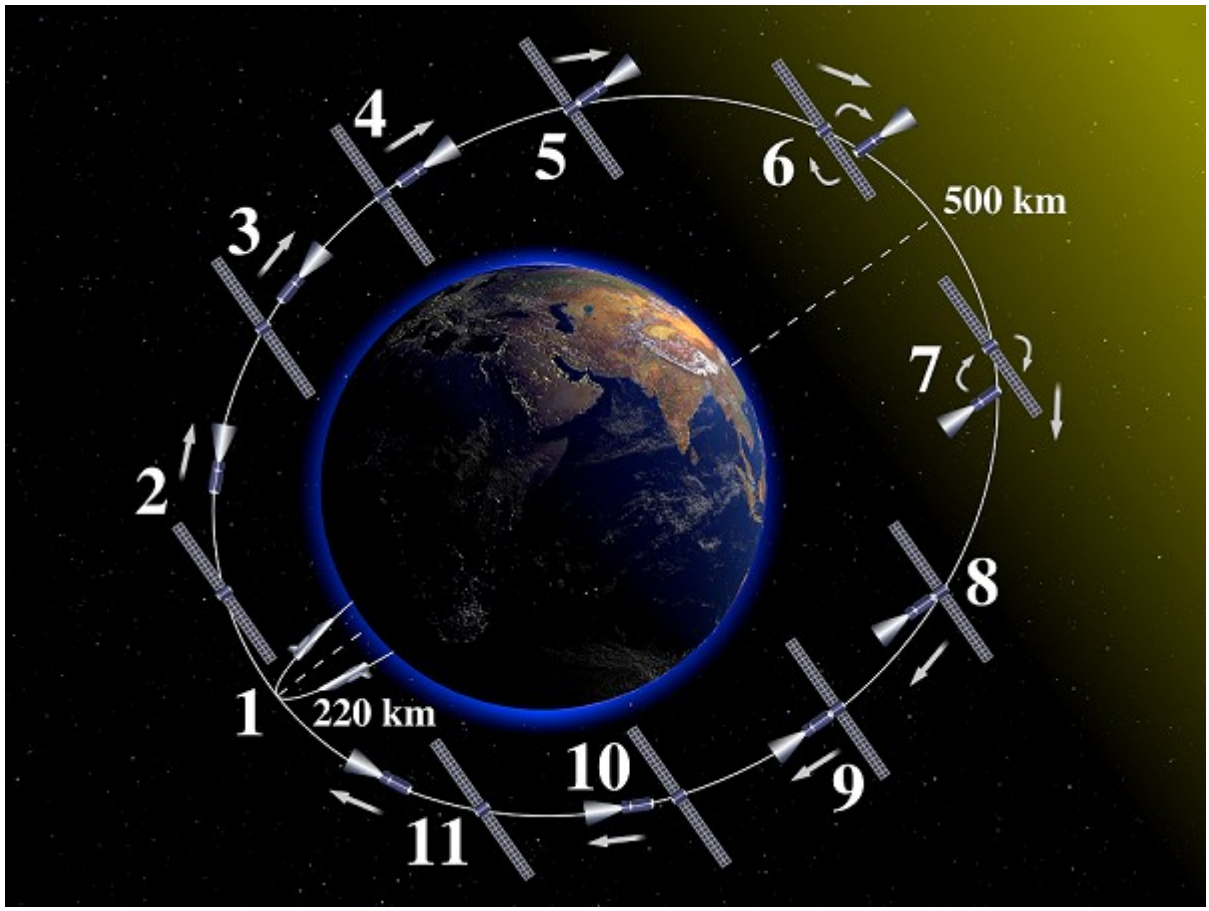
a) A CSC with elliptic trajectory and folding solar batteries.
b) A CSC with spiral trajectory and folding solar batteries with an engine arrangement (EA) on the basis of low-power EREs, or on the basis of an electrodynamic tether engine.
c) A CSC with cordless (fuel or accumulator) energy transmission to the EA from SB.
d) A CSC with a wired (cabled) energy transmission to the EA from SB.

The aforementioned variants are subdivided into the versions of the CSC to work with cargoes coming both from the Earth and from the Moon. At the same time lunar CSCs can be efficiently used to operate in circumterrestrial orbit in case of their usage in pair with suborbital rockets which accelerate cargoes for CSCs up to the speeds of 5500-6200 m/s.

Fig. 1. THE EARTH: THE SYSTEM OF CORDLESS ENERGY TRANSMISSION FROM SB

A CSC of 13500 kg mass and an autonomous SB block of 3100 kg mass with a cargo bay of 10400 kg mass for storage of liquid cargoes of up to 150 tons mass. All the system is put into orbit in two launches of the CR “Zenith-2”.
With apogee altitude equal to 500 km, the speed in perigee – 7858 m/s, with speed alterations by a value of around ±15 m/s (around 30 m/s in total).
Electric power of the membrane solar batteries (SB) – 6,22 MW
Electric power of the fuel cells (FC) – 3.73 MW
Electric power of electrorocket engines (ERE) – 3.73 MW.
ERE efficiency – 0.6

FC charging efficiency – 0.6
ERE specific pulse 31750 m/s
SB mass – 3100 kg (0.5 kg/KW)
FC mass – 3700 kg (1 kg/KW)
ERE mass – 2775 kg (0.75 kg/KW)
Cargoes' catcher mass – 1000 kg.
The rest equipment mass – 6025 kg.
Mass of the captured portion of cargo – 50 kg.
Length of the track of the cargo substance – 8000m.
Time of track capturing – 1 s.
Acceleration of braking in course of cargo capturing – 29.1 m/s^2 (~3 g).
Number of operations on cargo capturing for 1 year – 500.
Mass of the captured cargo for 1 year – 250 tons.
Mass of the cargo used in ERE for 1 year – 62.5 tons.
Mass of the cargo accumulated in the orbit for 1 year – 187.5 tons.
The fleet of multiuse suborbital rockets for exploitation in course of 1 year – 12-25 pieces (with 200-400 launches/rocket endurance).

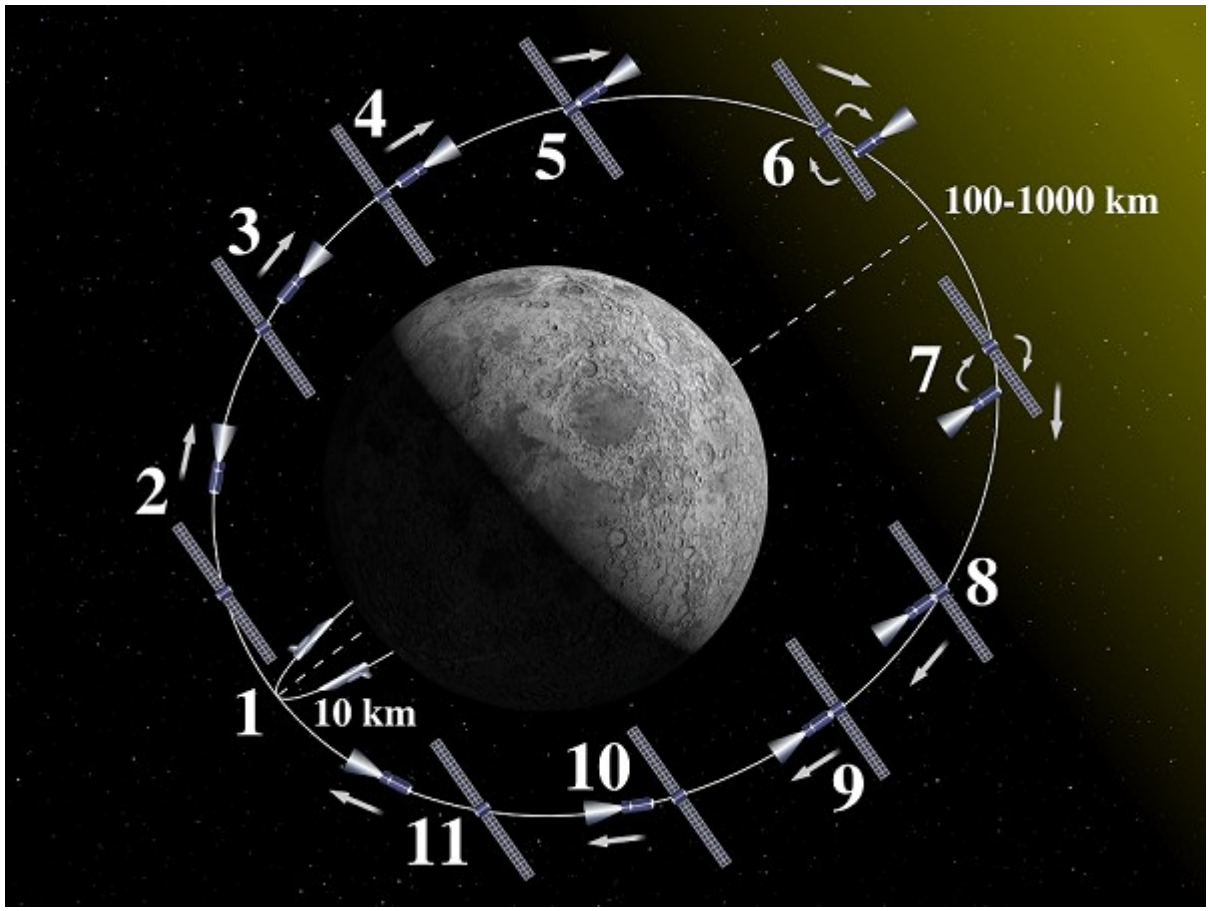


1 - The point (segment) of the CSC meeting with the track of the substance lifted from the Earth by a suborbital rocketplane. Collision of the CSC with the track at the speed exceeding the local one in perigee by approximately 15m/s. Loss of speed by around 30 m/s on absolute value or the CSC speed reduction by 15 m/s relative to the local perigee one.
1-2, 2-3 and **3-4** – The segment of the CSC acceleration (~22 minutes) by the on-board electrorocket engines (ERE) with incrementation by a value of 15.6 m/s for compensation of speed loss caused by capturing of substance in point 1. Compensation of speed lost after capturing of a portion of cargo. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.

4-5 – The segment of the CSC and the autonomous SB block speeds equalization, the zone of the CSC docking with the SB block.
5-6 – The segment of transmission of the captured cargo portion into the cargo bay of the SB block.
6-7 –The segment of separation (undocking) of the CSC from the SB block, changing of its position in the space.
7-8 – The segment of completion of the CSC and the SB block relative movements and their docking.
8-9 – The segment of displacement of combustible oxidation products from FCs in the CSC to the SB block for their regeneration and transmission of a new fuel portion for FC (combustible and oxidant) from the SB block to the CSC.
9-10, 10-11 and **11-1 –** The segment of preliminary acceleration of the CSC (~22 minutes) by the on-board electrorocket engines (ERE) with incrementation by a value of 15.6 m/s for compensation of a half of future speed loss after capturing of the substance in point 1. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.

Fig. 2. THE MOON: THE SYSTEM OF CORDLESS ENERGY TRANSMISSION FROM SB

A CSC of 4250 kg mass and an autonomous SB block of 117 kg mass with a cargo bay of 1000 kg mass for storage of liquid cargoes up to 10 tons mass.
With apolune altitude equal to 100 km, the speed in perilune – 1695 m/s, with speed alterations by a value of around ± 10 m/s (around 20 m/s in total).
Electric power of the membrane solar batteries (SB) – 0.222 MW.
Electric power of the fuel cells (FC) – 0.133 MW.
Electric power of electrorocket engines (ERE) – 0.133 MW.
ERE efficiency – 0.6
FC charging efficiency – 0.6
ERE specific pulse 6780 m/s



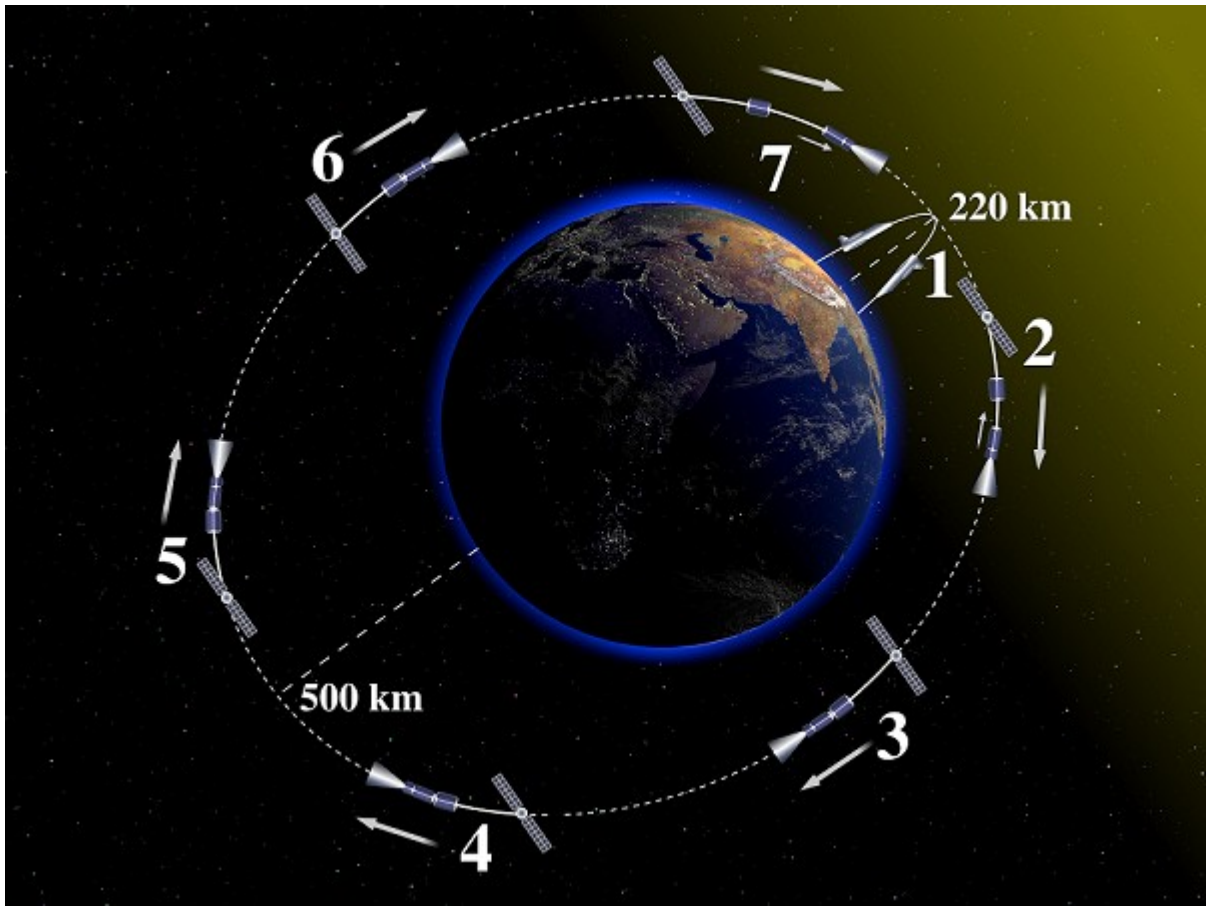
SB mass – 117 kg (0.5 kg/KW)
FC mass – 133 kg (1 kg/KW)
ERE mass – 100 kg (0.75 kg/KW)
Cargoes' catcher mass – 500 kg.
The rest equipment mass – 3511 kg.
Mass of the captured portion of cargo – 50 kg.
Length of the track of the cargo substance – 1700m.
Time of track capturing – 1 s.
Acceleration of braking in course of cargo capturing – 9.97 m/s^2 (~1 g).
Number of operations on cargo capturing for 1 year – 4000.
Mass of the captured cargo for 1 year – 200 tons.
Mass of the cargo used in ERE for 1 year – 50 tons.
Mass of the cargo accumulated in the orbit for 1 year – 150 tons.
In case of usage of ERE with specific pulse of 13600 m/s with electric power of 0.266 MW, the mass of the cargo accumulated for 1 year is growing up to 175 tons with the CSC's own mass of not more than 4.5 tons.
The fleet of multiuse lunar suborbital rockets (rocket lifts) for exploitation in course of 1 year – 2-4 pieces.

1 - The point (segment) of the CSC meeting with the track of the substance lifted from the Moon by a suborbital multiuse rocket. Collision of the CSC with the track at the speed exceeding the local one in perilune by approximately 10m/s. Loss of speed by around 20 m/s on absolute value or the CSC speed reduction by 10 m/s relative to the local one in perilune.
1-2, 2-3 and **3-4** – The segment of the CSC acceleration (~30 minutes) by the on-board electrorocket engines (ERE) with incrementation by a value of 9.97 m/s for compensation of speed loss caused by capturing of substance in point 1. Compensation of speed lost after capturing of a portion of cargo. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.
4-5 – The segment of the CSC and the autonomous SB block speeds equalization, the zone of the CSC docking with the SB block.
5-6 – The segment of transmission of the captured cargo portion into the cargo bay of the SB block.
6-7 – The segment of separation (undocking) of the CSC from the SB block, changing of its position in the space.
7-8 – The segment of completion of the CSC and the SB block relative movements and their docking.
8-9 – The segment of displacement of combustible oxida-tion products from FCs in the CSC to the SB block for their regeneration and transmission of a new fuel portion for FC (combustible and oxidant) from the SB block to the CSC.
9-10, 10-11 and **11-1 –** The segment of preliminary acceleration of the CSC (~30 minutes) by the on-board electrorocket engines (ERE) with incrementation by a value of 9.97 m/s for compensation of a half of future speed loss after capturing of the substance in point 1. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.

Fig. 3. THE EARTH: THE SYSTEM WITH ELECTRIC CABLE

A CSC of 13500 kg mass, an SB block of 1900 kg mass and a depot-block (a tanker) of 11600 kg mass for storage of liquid and solid cargoes of up to 180 tons mass. The SB block is connected by an electric cable of invariable length with the depot-block which in its turn is connected with the CSC by an electric cable of variable length (at the account of usage of a reel-to-reel mechanism of the cable winding and unwinding). Correspondingly fuel cells are not used for the ERE energy supply. All the system is put into orbit in two launches of the CR "Zenith-2".
With apogee altitude equal to 500 km, the speed in perigee – 7858 m/s (220 km altitude), with speed

alterations by a value of around ±15 m/s (around 30 m/s in total).
Electric power of the membrane solar batteries (SB) – 3.73 MW
Electric power of electrorocket engines (ERE) – 3.73 MW.
ERE specific pulse 31750 m/s
SB mass – 1900 kg (0.5 kg/KW)
ERE mass – 2800 kg (0.75 kg/KW)
Cargoes' catcher mass – 1000 kg.
The rest equipment mass – 9700 kg.
Mass of the captured portion of cargo – 50 kg.
Maximal length of the CSC electric cable – 11000 m.
Length of the track of the cargo substance – 8000 m.
Time of track capturing – 1 s.
Acceleration of braking in course of cargo capturing – 29.1 m/s^2 (~3 g).
Number of operations on cargo capturing for 1 year – 5000.
Mass of the captured cargo for 1 year – 250 tons.
Mass of the cargo used in ERE for 1 year – 62.5 tons.
Mass of the cargo accumulated in the orbit for 1 year – 187.5 tons.
The fleet of multiuse suborbital rockets for exploitation in course of 1 year – 12-25 pieces (with 200-400 launches/rocket endurance).

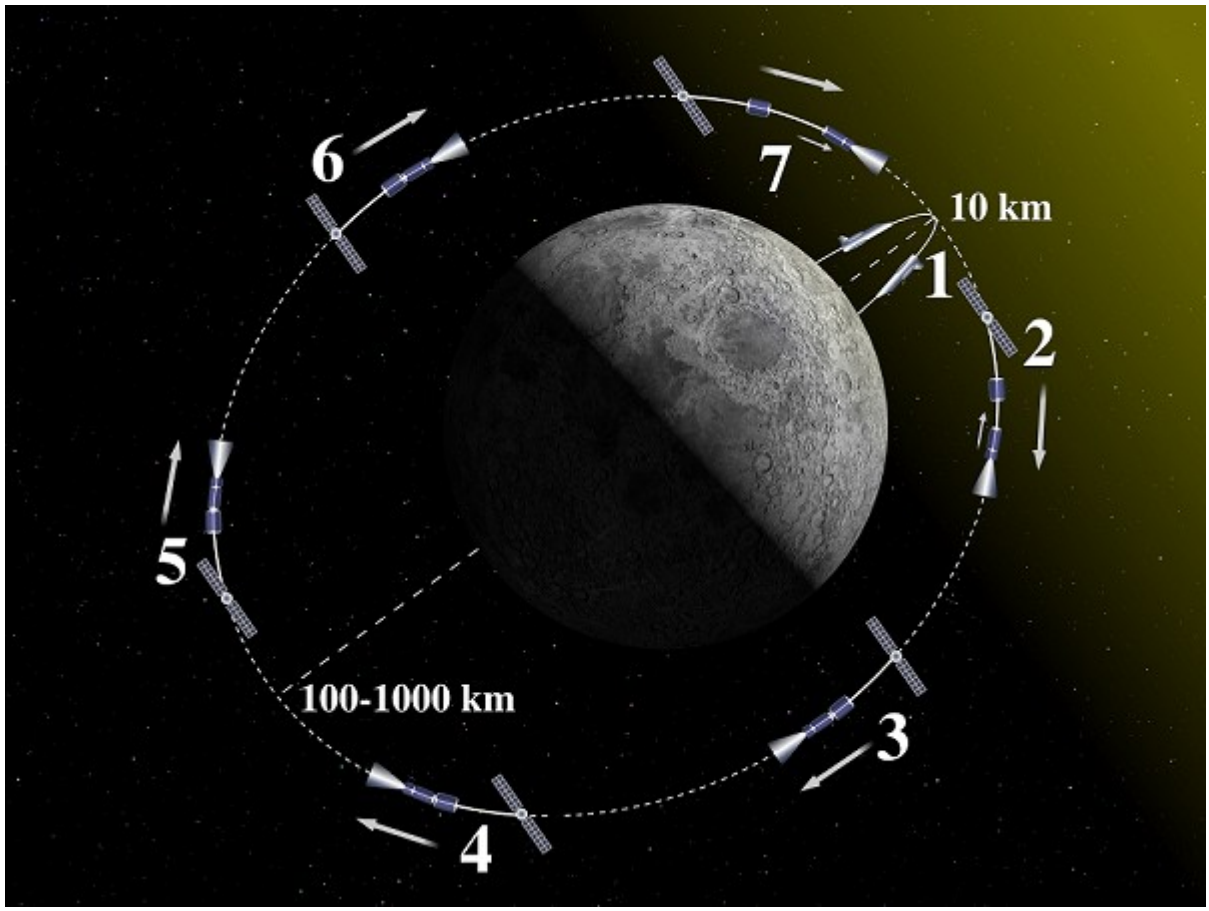


1 - The point (segment) of the CSC meeting with the track of the substance lifted from the Earth by a suborbital rocketplane. Collision of the CSC with the track at the speed exceeding the local one in perigee by approximately 15m/s. Loss of speed by around 30 m/s on absolute value or the CSC speed reduction by 15 m/s relative to the local perigee one.
1-2, 2-3 – The segment of the CSC acceleration (~22 minutes) by the on-board electrorocket engines (ERE)
with incrementation by a value of 15.6 m/s for compensation of a half of future speed loss after

capturing of the substance in point 1. Compensation of speed lost after capturing of a portion of cargo, equalization of the CSC speed with the speeds of the SB block and the depot-block. Complete winding of the CSC electric cable. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.
3-4, 4-5 and **5-6** – Docking of the CSC with the depot-block and pumping of the captured cargo into the tanker.
6-7 and **7-1 –** The segment of preliminary acceleration of the CSC (~22 minutes) by the on-board electrorocket engines (ERE) with incrementation by a value of 15.6 m/s for compensation of a half of future speed loss after capturing of the substance in point 1. Full unwinding of the CSC electric cable. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.

Fig. 4. THE MOON: THE SYSTEM WITH ELECTRIC CABLE

A CSC of 4250 kg mass, an SB block of 70 kg mass and a depot-block (a tanker) of 1000 kg mass for storage of liquid and solid cargoes of up to 10 tons mass. The SB block is connected by an electric cable of invariable length with the depot-block which in its turn is connected with the CSC by an electric cable of variable length (at the account of usage of a reel-to-reel mechanism of the cable unwinding and winding). Correspondingly fuel cells are not used for the ERE energy supply.
With apolune altitude equal to 100 km, the speed in perilune – 1695 m/s (10 km altitude), with speed alterations by a value of around ± 10 m/s (around 20 m/s in total).
Electric power of the membrane solar batteries (SB) – 0.133 MW
Electric power of electrorocket engines (ERE) – 0.133 MW.
ERE specific pulse 6780 m/s
SB mass – 70 kg (0.5 kg/KW)
ERE mass – 100 kg (0.75 kg/KW)



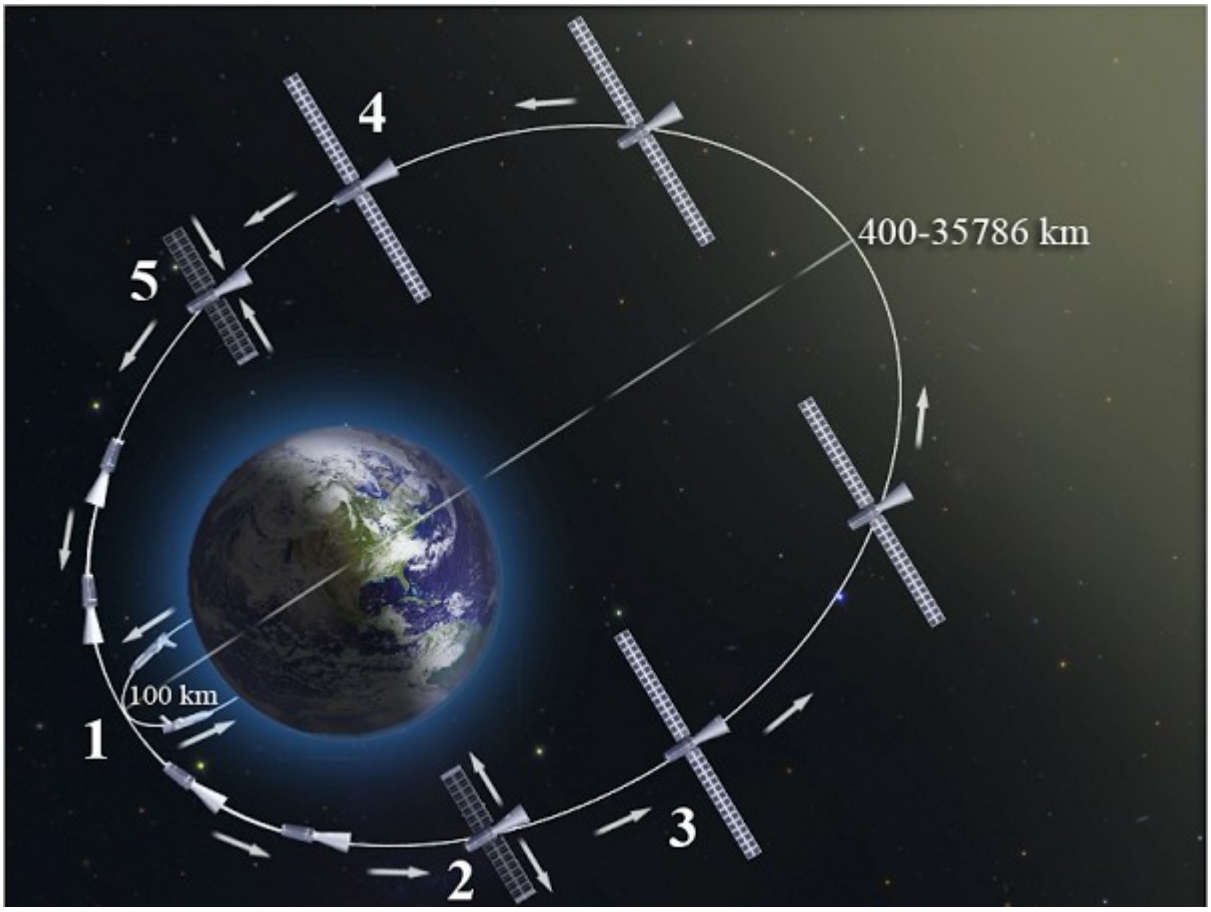
Cargoes' catcher mass – 500 kg.
The rest equipment mass – 3511 kg.
Mass of the captured portion of cargo – 50 kg.
Maximal length of the CSC electric cable – 9000 m.
Length of the track of the cargo substance – 1700m.
Time of track capturing – 1 s.
Acceleration of braking in course of cargo capturing – 9.97 m/s^2 (~1 g).
Number of operations on cargo capturing for 1 year – 4000.
Mass of the captured cargo for 1 year – 200 tons.
Mass of the cargo used in ERE for 1 year – 50 tons.
Mass of the cargo accumulated in the orbit for 1 year – 150 tons.
The fleet of multiuse lunar suborbital rockets (rocket lifts) for exploitation in course of 1 year – 2-4 pieces.

1 - The point (segment) of the CSC meeting with the track of the substance lifted from the Moon by a multiuse suborbital rocket. Collision of the CSC with the track at the speed exceeding the local one in perilune by approximately 10 m/s. Loss of speed by around 20 m/s on absolute value or the CSC speed reduction by 10 m/s relative to the local perilune one.
1-2, 2-3 – The segment of the CSC acceleration (~30 minutes) by the on-board electrorocket engines (ERE)
with incrementation by a value of 9.97 m/s for compensation of a half of future speed loss after capturing of the substance in point 1. Compensation of speed lost after capturing of a portion of cargo, equalization of the CSC speed with the speeds of the SB block and the depot-block. Complete winding of the CSC electric cable. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.
3-4, 4-5 and **5-6** – Docking of the CSC with the depot-block and pumping of the captured cargo into the tanker.
6-7 and **7-1 –** The segment of preliminary acceleration of the CSC (~30 minutes) by the on-board electrorocket engines (ERE) with incrementation by a value of 9.97 m/s for compensation of a half of future speed loss after capturing of the substance in point 1. Full unwinding of the CSC electric cable. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.

Fig. 5. THE EARTH: THE SYSTEM WITH FOLDING SOLAR BATTERIES

A CSC of 20000 kg mass.
With apogee altitude equal to 400 km, the speed in perigee – 7937 m/s, with speed alterations by a value of around ±10 m/s (around 20 m/s in total).
Electric power of the membrane solar batteries (SB) – 6.628 MW.
Electric power of the fuel cells (FC) – 3.98 MW.
Electric power of electrorocket engines (ERE) – 3.98 MW.
ERE efficiency – 0.6
FC charging efficiency – 0.6
ERE specific pulse 31750 m/s
SB mass – 3314 kg (0.5 kg/KW)
FC mass – 3980 kg (1 kg/KW)
ERE mass – 2980 kg (0.75 kg/KW)
Cargoes' catcher mass – 1000 kg.
The rest equipment mass – 8726 kg.
Mass of the captured portion of cargo – 50 kg.
Length of the track of the cargo substance – 8000m.

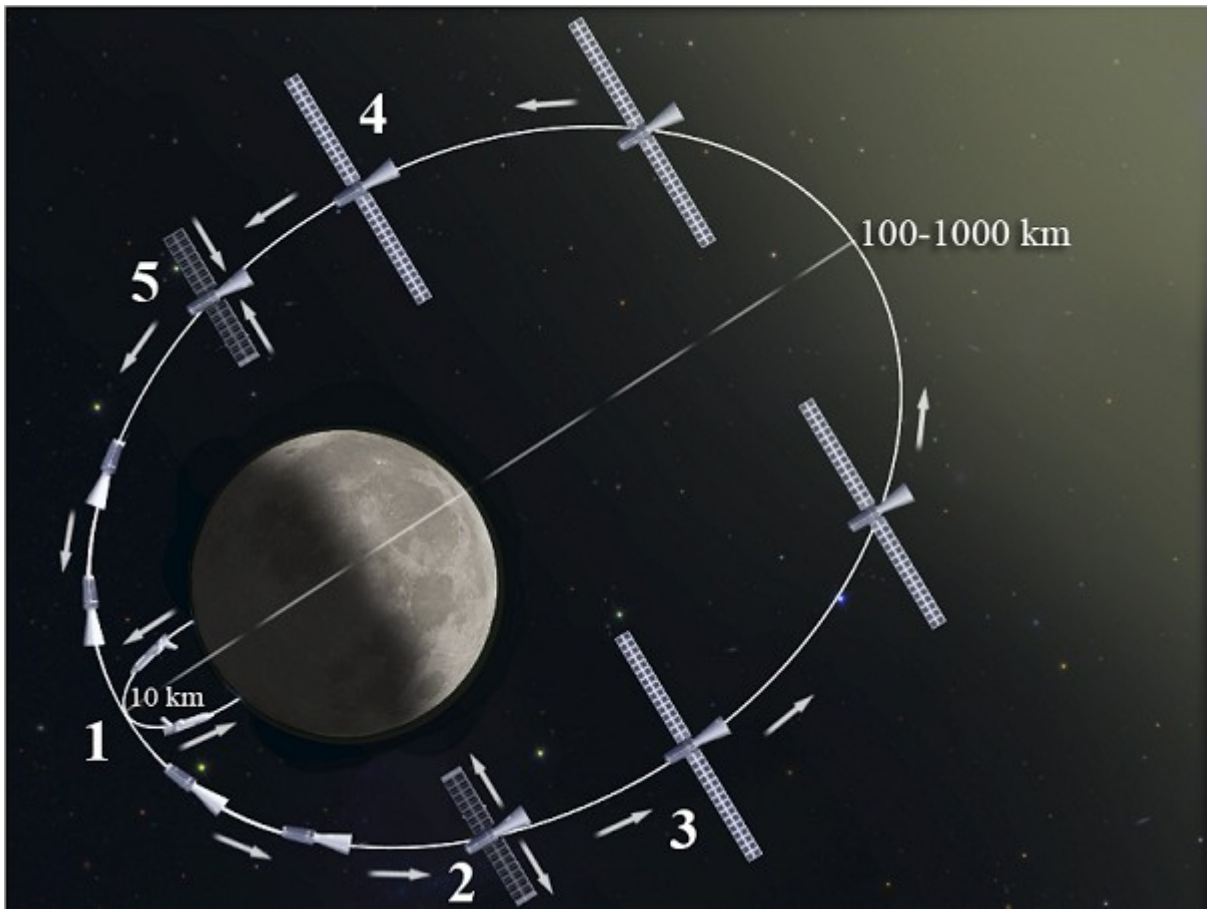
Time of track capturing – 1 s.
Acceleration of braking in course of cargo capturing – 19.84 m/s^2 (~2 g).
Number of operations on cargo capturing for 1 year – 5000.
Mass of the captured cargo for 1 year – 250 tons.
Mass of the cargo used in ERE for 1 year – 62.5 tons.
Mass of the cargo accumulated in the orbit for 1 year – 187.5 tons.
The fleet of multiuse suborbital rockets for exploitation in course of 1 year – 12-25 pieces (with 200-400 launches/rocket endurance).



1 - The point (segment) of the CSC meeting with the track of the substance lifted from the Earth by a suborbital rocketplane.
1-2 – The segment of the CSC acceleration (~20 minutes) by the on-board electrorocket engines (ERE) for compensation of speed loss caused by capturing of the substance in point 1. Compensation of speed of around 10m/s lost after capturing of a portion of cargo. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.
2-3 – The segment of unfolding of the membrane solar batteries (SB). SB's unfolding is fulfilled at the account of creation of centrifugal forces by the CSC rotation or microtraction of auxiliary EREs.
3-4 – The segment of flight (~40 minutes) with unfolded membrane SBs, restoration of protective layer of device for receiving cargoes of the cargoes' catcher, accumulated heat discharging and recharging of fuel cells for compensation of energy consumed for CSC acceleration in segments 5-1 and 1-2.
4-5 – The segment of folding of the membrane SBs.
5-1 – The segment of preemptive (preliminary) acceleration of the CSC (~20 minutes) by the on-board electrorocket engines (ERE) for compensation of speed loss which will take place after capturing of the substance in point 1. Speed incrementation 10 m/s. Further capturing of cargo of 50 kg mass and correspondingly loss of speed by a double incrementation value – by 20 m/s. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.

Fig. 6. THE MOON: THE SYSTEM WITH FOLDING SOLAR BATTERIES

A CSC of 4250 kg mass.
With apolune altitude equal to 100 km, the speed in perilune – 1695 m/s, with speed alterations by a value of around ±10 m/s.
Electric power of the membrane solar batteries (SB) – 0.222 MW.
Electric power of the fuel cells (FC) – 0.133 MW.
Electric power of electrorocket engines (ERE) – 0.133 MW.
ERE efficiency – 0.6
FC charging efficiency – 0.6
ERE specific pulse 6780 m/s
SB mass – 111 kg (0.5 kg/KW)
FC mass – 133 kg (1 kg/KW)
ERE mass – 100 kg (0.75 kg/KW)
Cargoes' catcher mass – 500 kg.
The rest equipment mass – 3406 kg.
Mass of the captured portion of cargo – 50 kg.
Length of the track of the cargo substance – 1700 m.
Time of track capturing – 1 s.
Acceleration of braking in course of cargo capturing – 9.97 m/s^2 (~1g).
Number of operations on cargo capturing for 1 year – 4000.
Mass of the captured cargo for 1 year – 200 tons.
Mass of the cargo used in ERE for 1 year – 50 tons.
Mass of the cargo accumulated in the orbit for 1 year – 150 tons.
In case of usage of ERE with specific pulse of 13600 m/s with electric power of 0.266 MW, the mass of the cargo accumulated for 1 year is growing up to 175 tons with the CSC's own mass of not more than 4.5 tons.



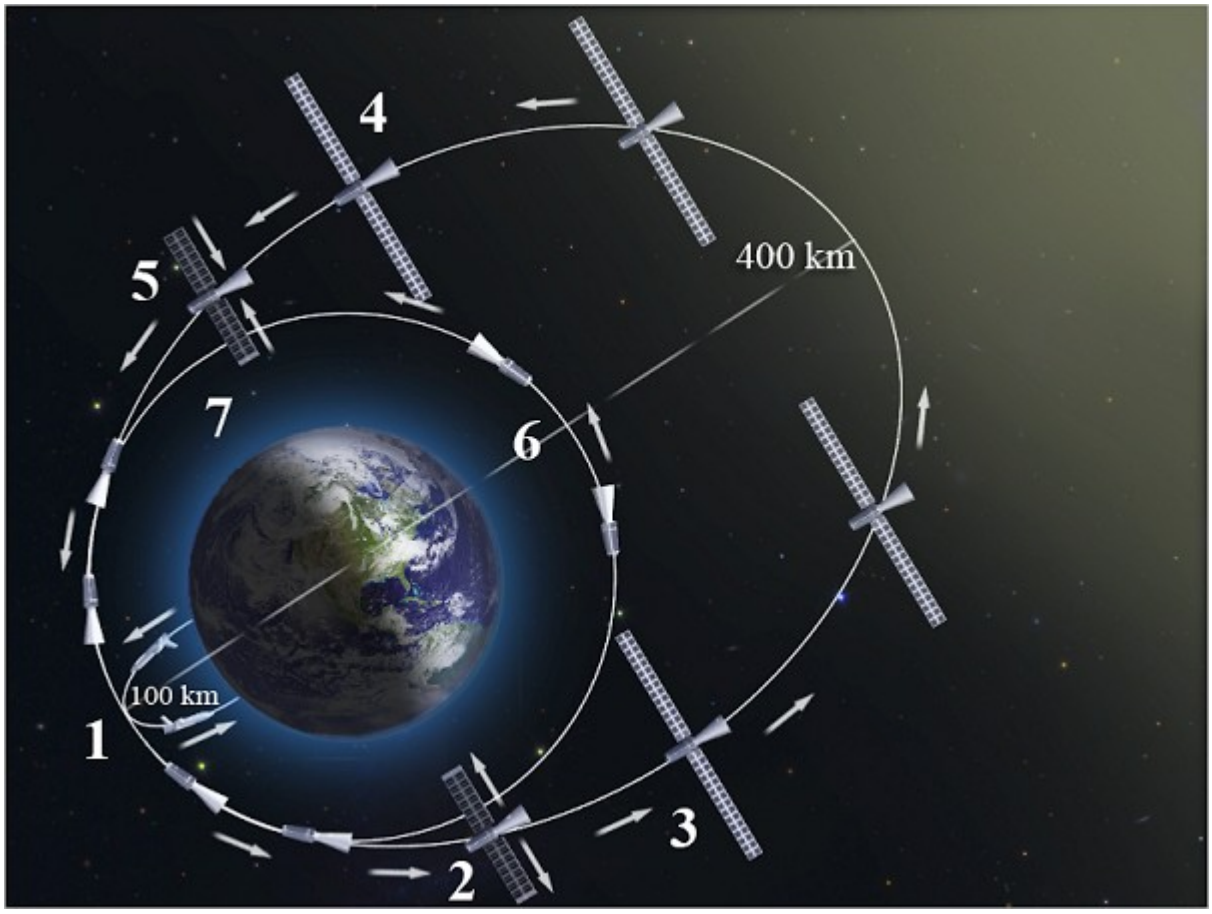
The fleet of multiuse lunar suborbital rockets (rocket lifts) for exploitation in course of 1 year – 2-4 pieces.

1 - The point (segment) of the CSC meeting with a track of substance (e.g., water) lifted from the Moon by a suborbital multiuse rocket.
1-2 – The segment of the CSC acceleration (~30 minutes) by the on-board electrorocket engines (ERE) for compensation of speed loss caused by capturing of substance in point 1. Compensation of speed of around 10m/s lost after capturing of a portion of cargo. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.
2-3 – The segment of unfolding of the membrane solar batteries (SB). SB's unfolding is fulfilled at the account of creation of centrifugal forces by the CSC rotation or microtraction of auxiliary EREs.
3-4 – The segment of flight (~60 minutes) with unfolded membrane SBs, restoration of protective layer of device for receiving cargoes of the cargoes' catcher, accumulated heat discharging and recharging of fuel cells for compensation of energy consumed for CSC acceleration in segments 5-1 and 1-2.
4-5 – The segment of folding of the membrane SBs.
5-1 – The segment of preemptive (preliminary) acceleration of the CSC (~30 minutes) by the on-board electrorocket engines (ERE) for compensation of speed loss which will take place after capturing of the substance in point 1. Speed incrementation 10 m/s. Further capturing of cargo of 50 kg mass and correspondingly loss of speed by a double incrementation value – by 20 m/s. Ellipticity of the trajectory in the segment of acceleration is provided compulsory by operation of correction EREs.

Fig. 7. THE EARTH: THE SYSTEM WITH FOLDING SOLAR BATTERIES

A CSC of 4460 kg mass.
With apogee altitude equal to 400 km, the speed in perigee – 7937 m/s.
The CSC speed in circular orbit – 7849 m/s.
Electric power of the membrane solar batteries (SB) – 1.945 MW.
Electric power of the fuel cells (FC) – 1.556 MW.
Electric power of electrorocket engines (ERE) – 1.556 MW.
ERE efficiency – 0.75
FC charging efficiency – 0.8
ERE specific pulse – 15700 m/s
SB mass – 780 kg (0.4 kg/KW)
FC mass – 780 kg (0.5 kg/KW)
ERE mass – 780 kg (0.5 kg/KW)
Cargoes' catcher mass – 500 kg.
The rest equipment mass – 1620 kg.
Mass of the captured portion of cargo – 50 kg.
Length of the track of the cargo substance – 16000m.
Time of track capturing – 2 s.
Acceleration of braking in course of cargo capturing – 44 m/s^2 (~4.5g).
Number of operations on cargo capturing for 1 year – 2500.
Mass of the captured cargo for 1 year – 125 tons.
Mass of the captured air for 1 year – 125 tons.
Mass of the air used in ERE for 1 year – 125 tons.
Mass of the cargo accumulated in the orbit for 1 year – 125 tons.
The fleet of multiuse suborbital rockets for exploitation in course of 1 year – 6-12 pieces (with 200-400 launches/rocket endurance).
In case of usage of ERE and FC with less specific power – 0.75 kg/KW and 1 kg/KW correspondingly, the CSC mass gets doubled with keeping up the possibility to fulfill the aforementioned scheme of

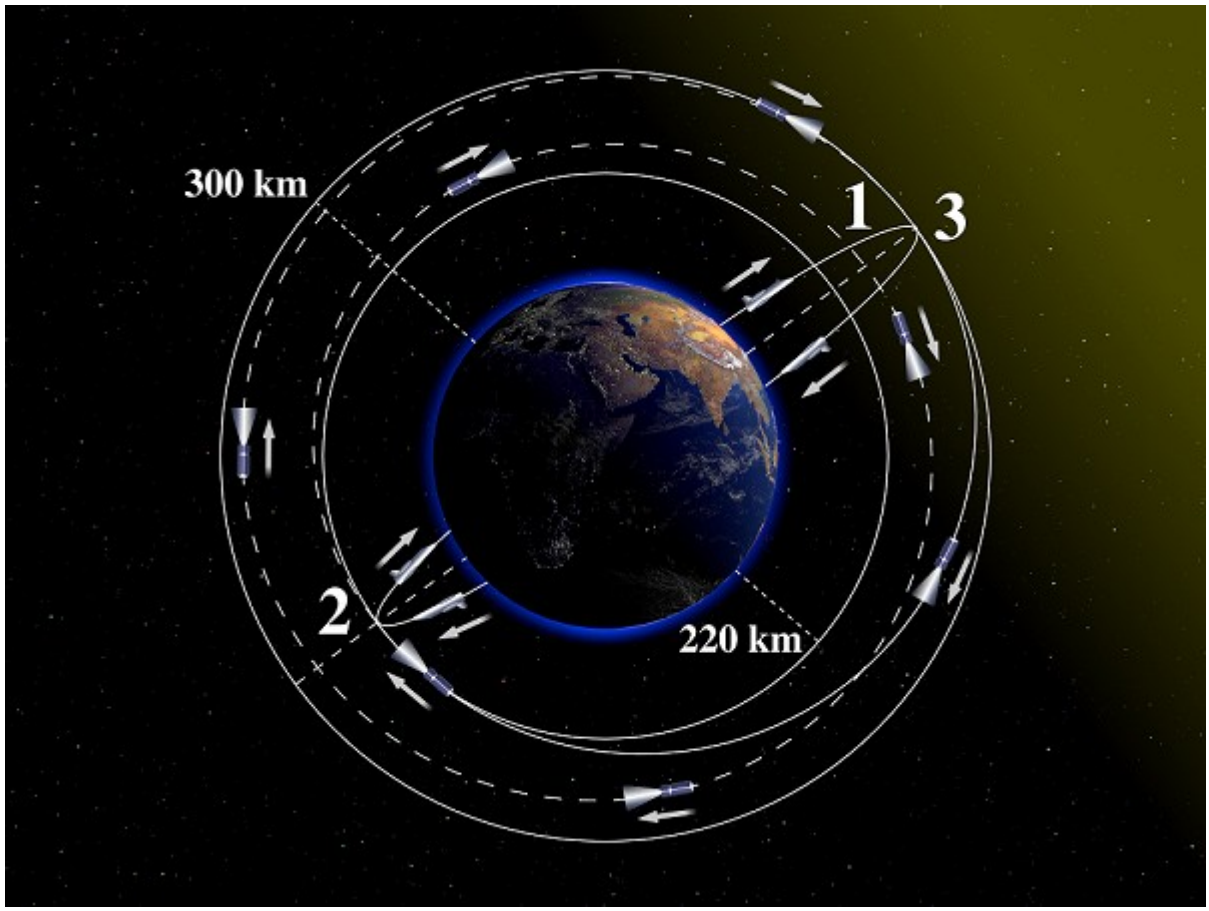
operation at the account of double circuits with half incrementation of speed on each of them by 44 m/s.



1 – The point (segment) of the CSC meeting with the track of the substance lifted from the Earth by a suborbital rocketplane.
1-2 – The segment of the CSC acceleration (~22 minutes) by the on-board electrorocket engines (ERE) for compensation of speed loss caused by capturing of the substance in point 1 (speed incrementation 88 m/s).
2-3 – The segment of unfolding of the membrane solar batteries (SB).
3-4 – The segment of flight with unfolded membrane SBs, restoration of protective layer of device for receiving cargoes of the cargoes' catcher, accumulated heat discharging and recharging of fuel cells for compensation of energy consumed for CSC acceleration in segments 5-1, 1-2 and 7-1 as well as capturing of air in segments 1-6 and 6-1.
4-5 – The segment of folding of the membrane SBs.
5-1 – The segment of preemptive (preliminary) acceleration of the CSC (~22 minutes) by the on-board electrorocket engines (ERE) for compensation of speed loss which will take place after capturing of the substance in point 1 (speed incrementation 88 m/s).
1-6 and **6-1** –The CSC's circular orbit (around 100 km altitude) where capturing of atmospheric air takes place with operation of EREs consuming nitrogen (or air) at the account of energy accumulated by CSC in segment 3-4.
7-1 – The segment of preemptive (preliminary) acceleration of the CSC (~22 minutes) by the on-board EREs for moving to elliptical orbit in point 1 (speed incrementation 88 m/s).

Fig. 8. THE EARTH: THE SYSTEM WITH THRUSTERS - ERE

A CSC of 16800 kg mass. SBs are not displayed.
The upper circular orbit – 7730 m/s.
Reduction of the CSC speed in the upper circular orbit in course of capturing of the first portion of cargo of 50 kg mass is 23 m/s.
Reduction of the CSC speed in perigee of the elliptical orbit in course of capturing of the second portion of cargo of 50 kg mass is 23 m/s.
The lower circular orbit – 7777 m/s.
Electric power of the membrane SB – 6.15 MW.
FC electric power – 2.5 MW.
ERE electric power – 2.5 MW.
ERE efficiency – 0.6
FC charging efficiency – 0.6
ERE specific pulse – 30920 m/s
SB mass – 3100 kg (0.5 kg/KW)
FC mass – 2500 kg (1 kg/KW)
ERE mass – 1900 kg (0.75 kg/KW)
Cargoes' catcher mass – 1000 kg.
The rest equipment mass – 8300 kg.
Mass of the captured portion of cargo – 50 kg.
Length of the track of the cargo substance – 8000m.
Time of track capturing – 1 s.
Acceleration of braking in course of cargo capturing – 23 m/s^2 (~2.3g).
Number of operations on cargo capturing in points 1 and 2 for 1 year – 8000.
Mass of the captured cargo for 1 year – 400 tons.
Mass of the cargo used in ERE for 1 year – 100 tons.

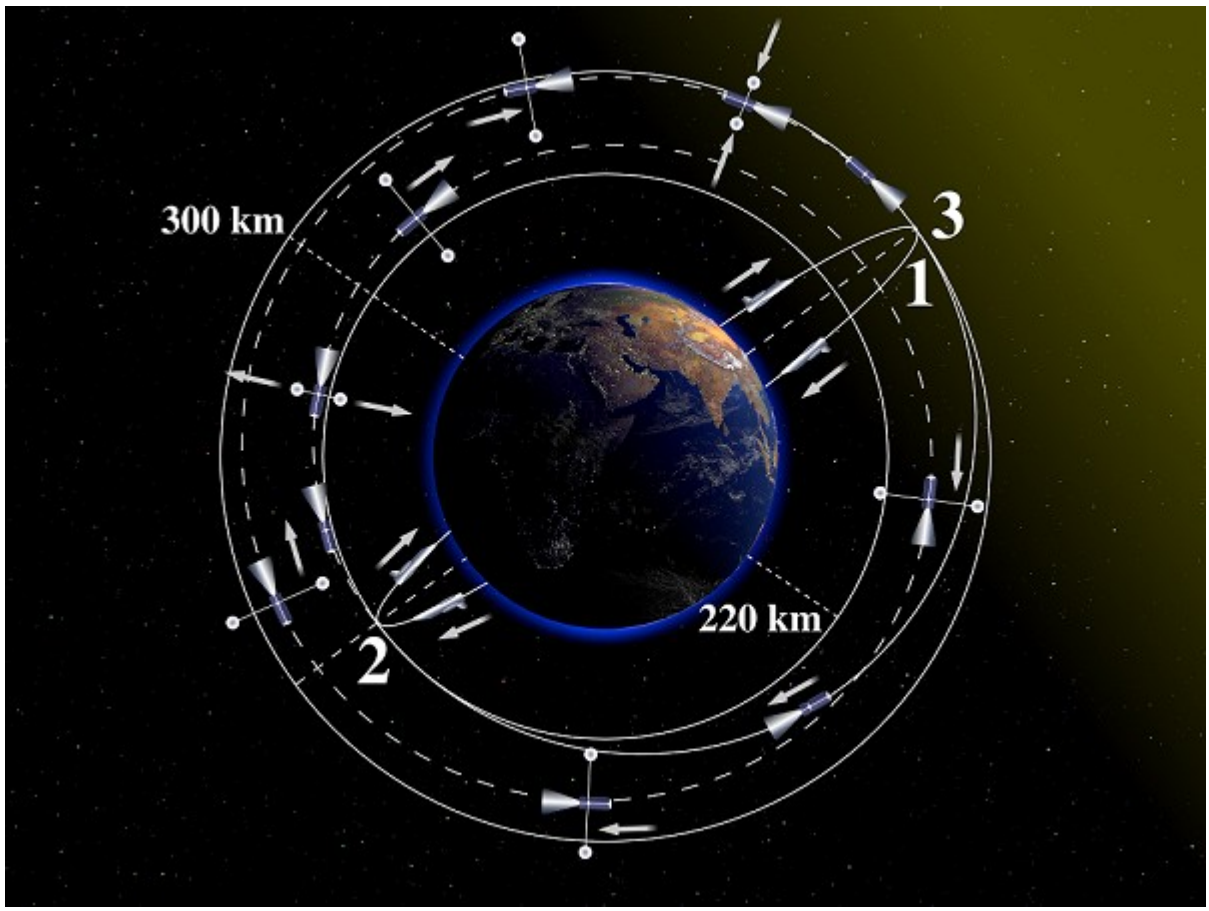


Mass of the cargo accumulated in the orbit for 1 year – 300 tons.
The fleet of multiuse suborbital rockets for exploitation in course of 1 year – 20-40 pieces (with 200-400 launches/rocket endurance).

1 - The first point (segment) of the CSC meeting with the track of the substance lifted from the Earth by a suborbital rocketplane to the level of the CSC upper circular orbit.
1-2 – The segment of the CSC descending movement (~45 minutes) along the elliptical orbit after getting the braking pulse in the result of capturing of a cargo portion in point (segment) 1. In course of movement along this segment there also fulfilled in automatic mode difFCrent technological procedures on FC energy supply and servicing of the cargoes' catcher.
2 – The second point (segment) of the CSC meeting with the track of the substance lifted from the Earth by a suborbital rocketplane to the level of the CSC lower circular orbit. Getting of the second braking pulse moving the CSC to the circular orbit from the elliptical one.
2-3 – The segment of the CSC ascending movement (~133 minutes) along the spiral trajectory from the lower circular orbit to the upper circular orbit under the influence of the ERE traction force. In course of movement along this segment there also fulfilled in automatic mode difFCrent technological procedures on FC energy supply and servicing of the cargoes' catcher.

Fig. 9. THE EARTH: THE SYSTEM WITH THRUSTERS - EDTS

A CSC of 16800 kg mass with electrodynamic tether system (EDTS). SBs are not displayed.
The upper circular orbit (300 km altitude)– 7730 m/s.
Reduction of the CSC speed in the upper circular orbit in course of capturing of the first portion of cargo of 50 kg mass is 23 m/s.
Reduction of the CSC speed in perigee of the elliptical orbit in course of capturing of the second portion of cargo of 50 kg mass is 23 m/s.
The lower circular orbit (220 km altitude) – 7777 m/s.
Electric power of the membrane SB – 2.5 MW
FC electric power – 1 MW.
EDTS electric power – 1 MW.
FC charging efficiency – 0.6
SB mass – 1250 kg (0.5 kg/KW)
FC mass – 1000 kg (1 kg/KW)
EDTS mass – 5000 kg
Cargoes' catcher mass – 1000 kg.
The rest equipment mass – 8550 kg.
Mass of the captured portion of cargo – 50 kg.
Length of the track of the cargo substance – 8000 m.
Time of track capturing – 1 s.
Acceleration of braking in course of cargo capturing – 23 m/s^2 (~2.3g)
Number of operations on cargo capturing in points 1 and 2 for 1 year – 8000.
Mass of the captured cargo for 1 year – 400 tons.
Mass of the cargo used in correction ERE for 1 year – 0.1-1 tons.
Mass of the cargo accumulated in the orbit for 1 year – 400 tons.
The fleet of multiuse suborbital rockets for exploitation in course of 1 year – 20-40 pieces (with 200-400 launches/rocket endurance).

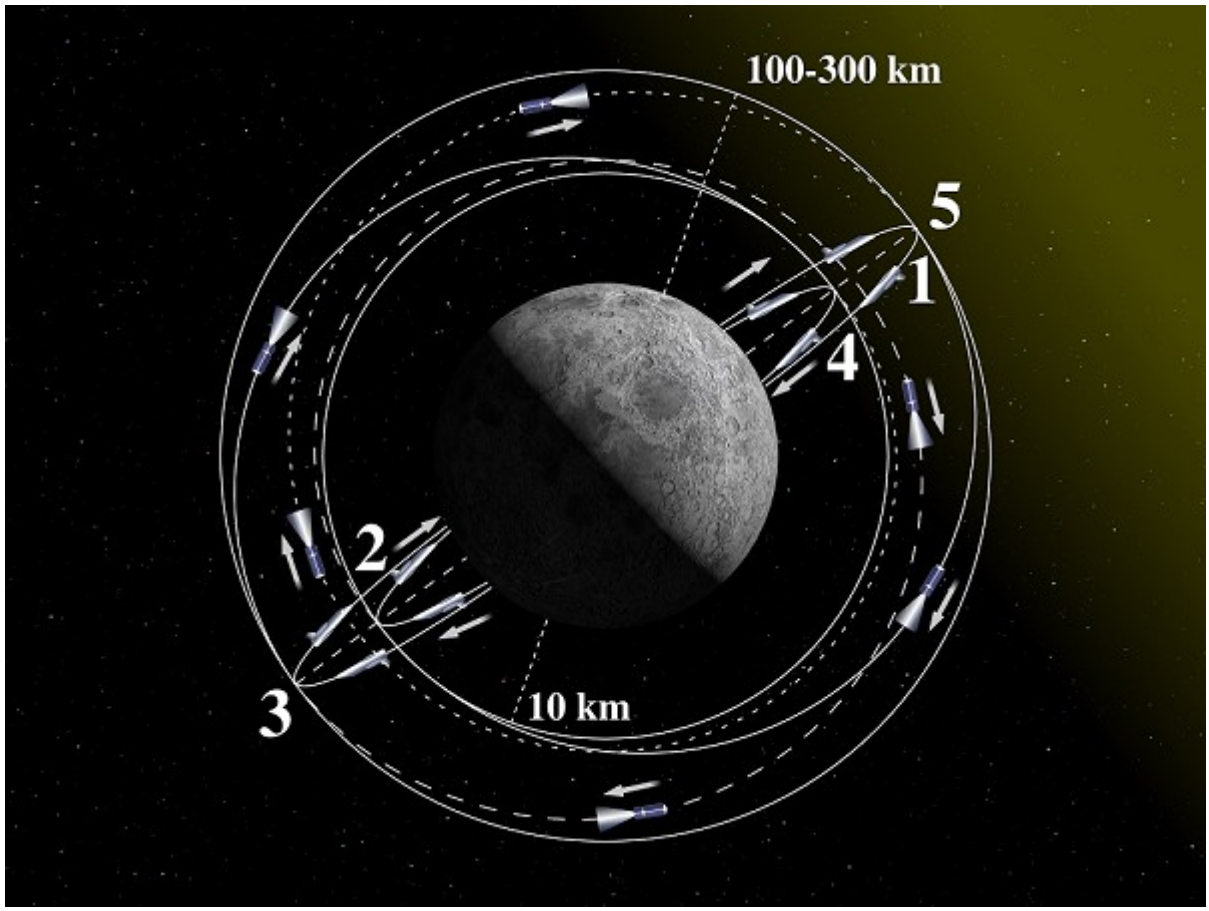


1 - The first point (segment) of the CSC meeting with the track of the substance lifted from the Earth by a suborbital rocketplane to the level of the CSC upper circular orbit.
1-2 – The segment of the CSC descending movement (~45 minutes) along the elliptical orbit after getting the braking pulse in the result of capturing of a cargo portion in point (segment) 1. In course of movement along this segment there also fulfilled in automatic mode difFCrent technological procedures on FC energy supply and servicing of the cargoes' catcher.
2 – The second point (segment) of the CSC meeting with the track of the substance lifted from the Earth by a suborbital rocketplane to the level of the CSC lower circular orbit. Getting of the second braking pulse moving the CSC to the circular orbit from the elliptical one.
2-3 – The segment of the CSC ascending movement (~133 minutes) along the spiral trajectory from the lower circular orbit to the upper circular orbit under the influence of traction force of the unfolded EDTS. In course of movement along this segment there also fulfilled in automatic mode difFCrent technological procedures on FC energy supply and servicing of the cargoes' catcher. On reaching of point 3 the EDTS's tethers get folded.

Fig. 10. THE MOON: THE SYSTEM WITH THRUSTERS

A CSC of 4250kg mass. SBs are not displayed. Possible to use nuclear electric generator instead of the SB.
With apolune altitude equal to 100 km, the speed in perilune – 1695 m/s, with speed reduction by 20 m/s the CSC moves to the lower circular orbit (10 km altitude).
Speed incrementation by 21 m/s moves the CSC to the upper circular orbit (100 km altitude).
Electric power of the membrane solar batteries (SB) – 0,156 MW.
Electric power of the fuel cells (FC) – 0.07 MW.
Electric power of electrorocket engines (ERE) – 0.07 MW.
ERE efficiency – 0.6

FC charging efficiency – 0.6
ERE specific pulse 6780 m/s
SB mass – 80 kg (0.5 kg/KW)
FC mass – 70 kg (1 kg/KW)
ERE mass – 60 kg (0.75 kg/KW)
Cargoes' catcher mass – 500 kg.
The rest equipment mass – 3540 kg.
Mass of the captured portion of cargo – 50 kg.
Length of the track of the cargo substance – 1700m.
Time of track capturing – 1 s.
Acceleration of braking in course of cargo capturing – 20-21 m/s^2 (~2 g).
Number of operations on cargo capturing for 1 year – 3000.
Mass of the captured cargo for 1 year – 150 tons.
Mass of the cargo used in ERE for 1 year – 37.5 tons.
Mass of the cargo accumulated in the orbit for 1 year – 112.5 tons.
The fleet of multiuse lunar suborbital rockets (rocket lifts) for exploitation in course of 1 year – 2-4 pieces.



1 - The first point (segment) of the CSC meeting with the track of the substance lifted from the Moon (e.g., water) by a suborbital multiuse rocket to the altitude of the CSC upper circular orbit.
1-2 – The segment of the CSC descending movement (~57 minutes) along the elliptical orbit after getting the braking pulse in the result of capturing of a cargo portion in point (segment) 1. In course of movement along this segment there also fulfilled in automatic mode difFCrent technological procedures on FC energy supply and servicing of the cargoes' catcher.
2 – The second point (segment) of the CSC meeting with the track of the substance lifted from the Moon by a suborbital multiuse rocket to the altitude of the CSC lower circular orbit. Getting of the second braking pulse moving the CSC to the circular orbit from the elliptical one in the result of

capturing of a cargo portion in point (segment) 2.
2-3 – The segment of the CSC ascending movement (~114 minutes) along the spiral trajectory from the lower circular orbit to the upper circular orbit under the influence of the ERE traction force. In course of movement along this segment there also fulfilled in automatic mode difFCrent technological procedures on FC energy supply and servicing of the cargoes' catcher.
3 – The third point (segment) of the CSC meeting with the track of the substance lifted from the Moon by a suborbital multiuse rocket to the altitude of the CSC upper circular orbit. Getting of the third braking pulse moving the CSC to the circular orbit from the elliptical one in the result of capturing of a cargo portion in point (segment) 3.
3-4 – The segment of the CSC descending movement (~57 minutes) along the elliptical orbit after getting the braking pulse in the result of capturing of a cargo portion in point (segment) 3. In course of movement along this segment there also fulfilled in automatic mode difFCrent technological procedures on FC energy supply and servicing of the cargoes' catcher.
4 – The fourth point (segment) of the CSC meeting with the track of the substance lifted from the Moon by a suborbital multiuse rocket to the altitude of the CSC lower circular orbit. Getting of the fourth braking pulse moving the CSC to the circular orbit from the elliptical one in the result of capturing of a cargo portion in point (segment) 4.
4-5 – The segment of the CSC ascending movement (~114 minutes) along the spiral trajectory from the lower circular orbit to the upper circular orbit under the influence of the ERE traction force. In course of movement along this segment there also fulfilled in automatic mode difFCrent technological procedures on FC energy supply and servicing of the cargoes' catcher.
5 – The point (segment) of the CSC meeting with the track of the substance lifted from the Moon by a suborbital multiuse rocket to the altitude of the CSC upper circular orbit. Coincides with point 1. Getting of braking pulse moving the CSC to the circular orbit from the elliptical one in the result of capturing of a cargo portion in point (segment) 5. Cycle completion.

COMMENTS

For calculation of orbits following physical and cosmodynamical characteristics of the Earth and the Moon have been applied:
Average radius of the Earth – 6370 km
Gravity parameter of the Earth – $3.9860 \cdot 10^5$ km^3/s^2
Average radius of the Moon – 1738 km
Gravity parameter of the Moon – $4.903 \cdot 10^3$ km^3/s^2