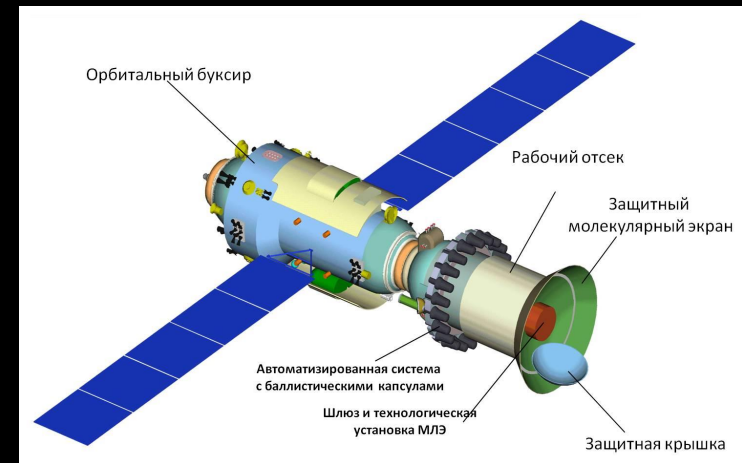
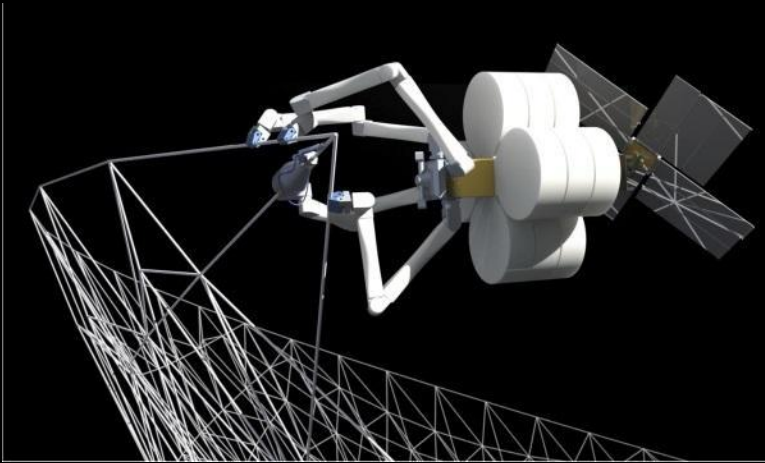


Space Cargoes Low-Cost Delivery Method

# Orbitron Project

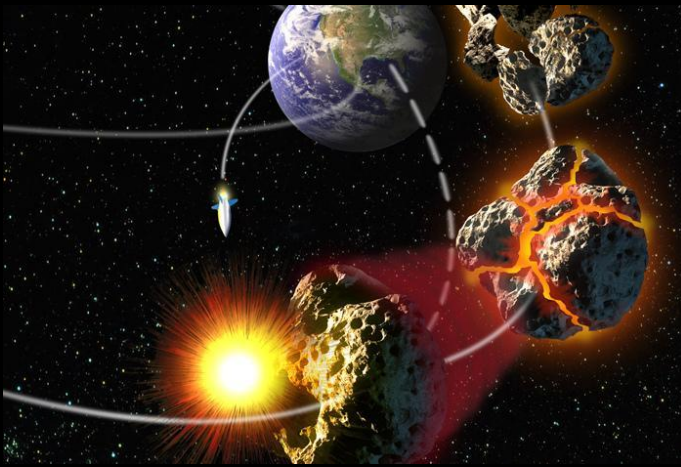
Alexander Mayboroda  
AVANTA Consulting

# Space Cargoes Delivery Problems



- Prices to deliver cargo into space are high. The cost of satellite launching to geostationary orbit (GEO) amounts to \$50 000 USD/kg.
- It is necessary for business development of space to reduce prices to 5-10% of current ones.

# Space Cargoes Delivery Problems



- To reduce prices it is essential for the planet protection from various space menaces.

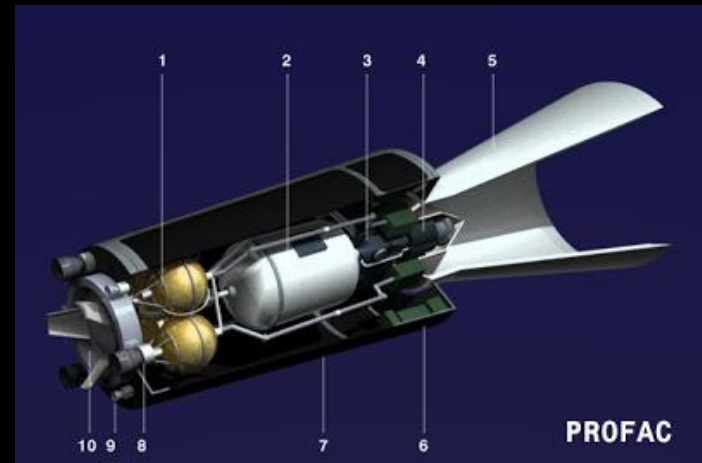
# Market Prospects



- Launching services market is growing. In 2013 the market size reached \$5.4 billion\*.
- In case of unit cost reduction by 10 times, annual profits of launching companies will amount to \$ 5 billion.

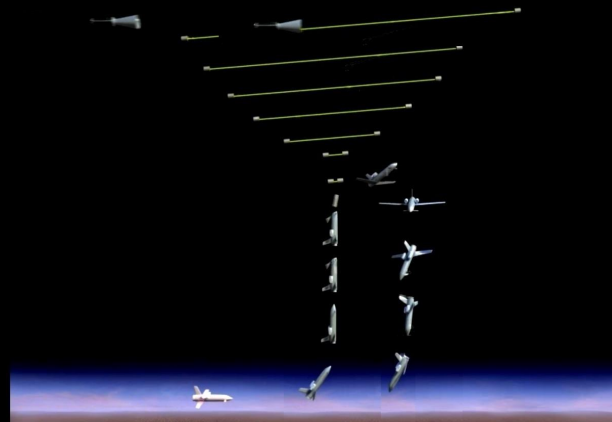
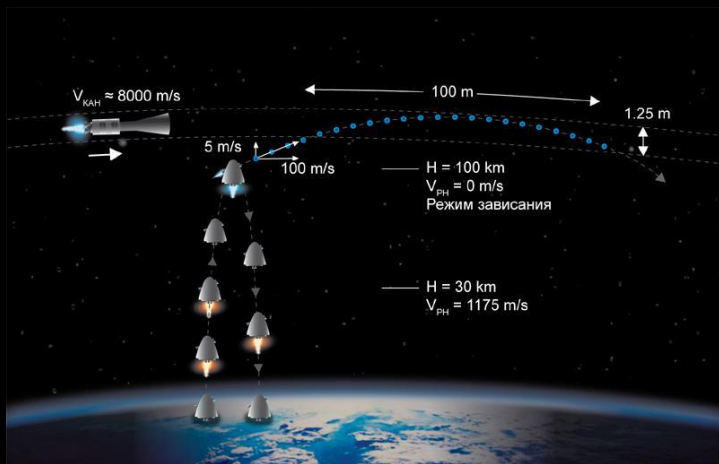
*\*) According to Satellite Industry Association (SIA) information on telecommunication, space and satellite industries revenues between 2001 and 2013.*

# General Direction to Solve the Problem



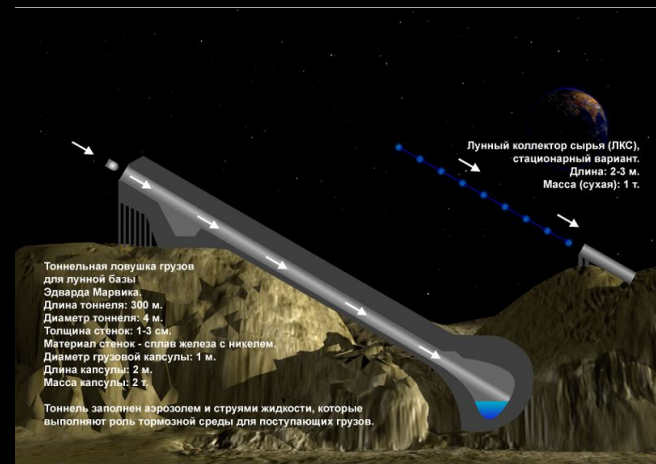
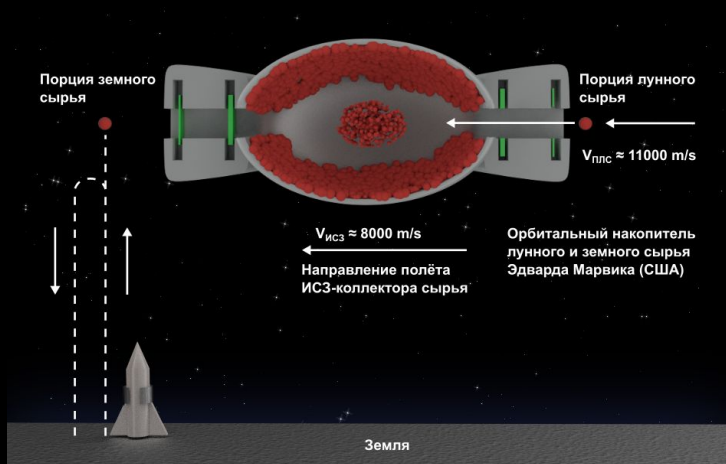
- Attempts to solve the problem are aspirations to create reusable space vehicles and to reduce prices by decreasing spacecraft depreciation & amortization expenses.
- Unfortunately, such projects are long overdue; and single use rockets (expendable spacecraft) are still being launched.

# Solution



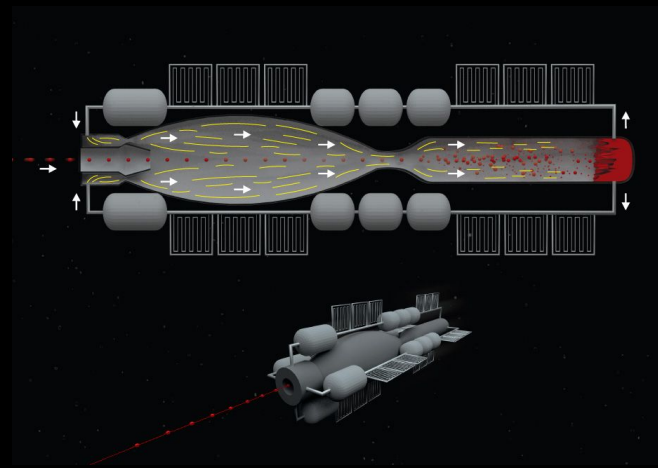
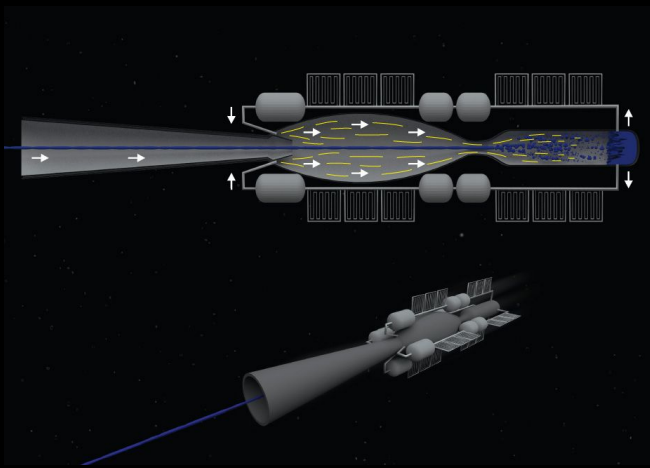
- The ORBITRON Project solves the problem of reusable space vehicles creation.

# Solution



- The prototype project is an US patent (US4775120 & US5199671), unimplemented because of the spacecraft huge mass of 40 000 tons.

# Solution



- The solution we propose reduces the mass of the American prototype to feasible.



# Orbitron, Orbital Substance Collector (OSC)

The developed space vehicle system consists of two parts:

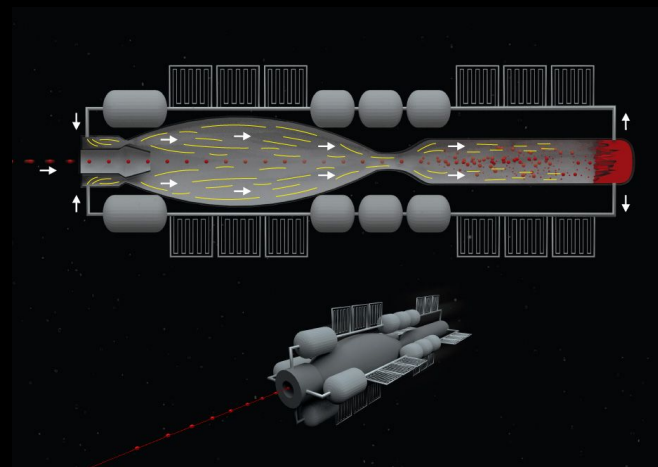
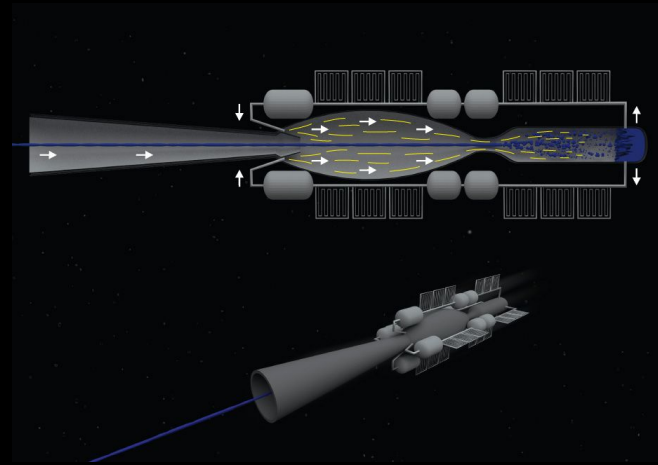
- The first part is an aerospace (land based) part based on suborbital rockets;
- The second part is an orbital cargo satellite collector.



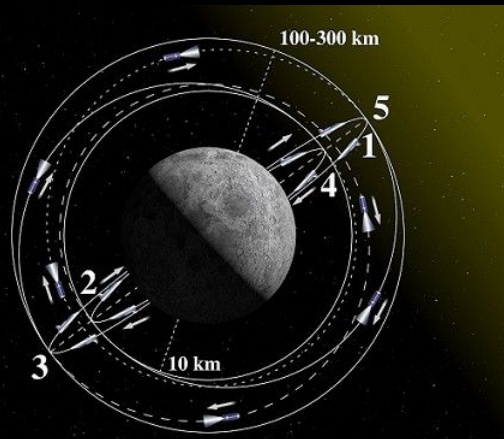
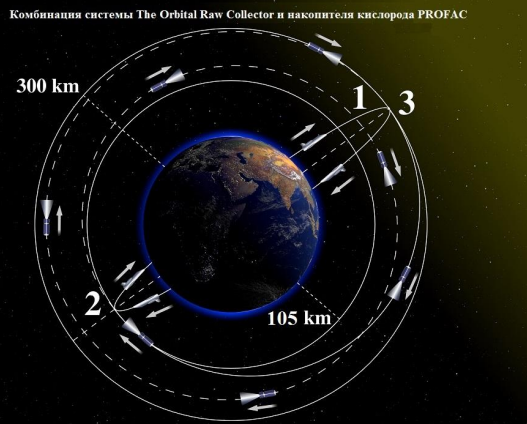
- Cargo is hoisted by suborbital rockets and then is ejected in front of the orbital collector.
- As a result of shock collision inside the collector, the portion of cargo accelerates up to the speed of the collector itself.
- After its kinetic energy is restored, the collector receives the next portion of cargo.

# Orbitron, Orbital Substance Collector (OSC)

- The developed spacecraft differs from the American prototype in the way cargo portions arrive into the collector gradually not simultaneously as a whole like in the prototype.
- To achieve this, Mylar film 2 micron thick and up to 8 000 meters long covered with special substances is used.
- As a result, shock impact on the collector is diminished and its mass can be reduced from 40 000 tons to 1-4 tons.

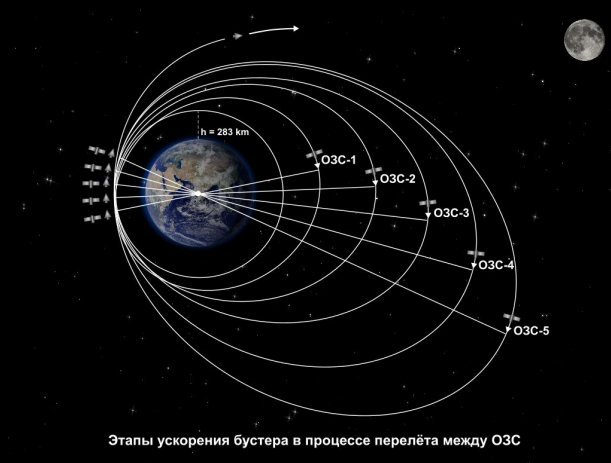


# Orbitron, Orbital Substance Collector (OSC)

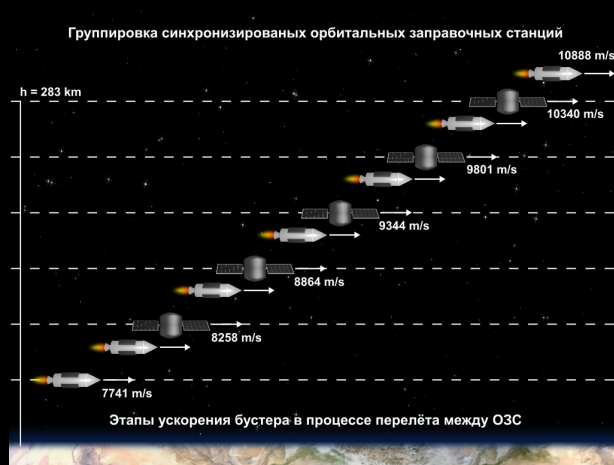


- Planet-Orbit basic model for the Earth.
- Planet-Orbit basic model for the Moon

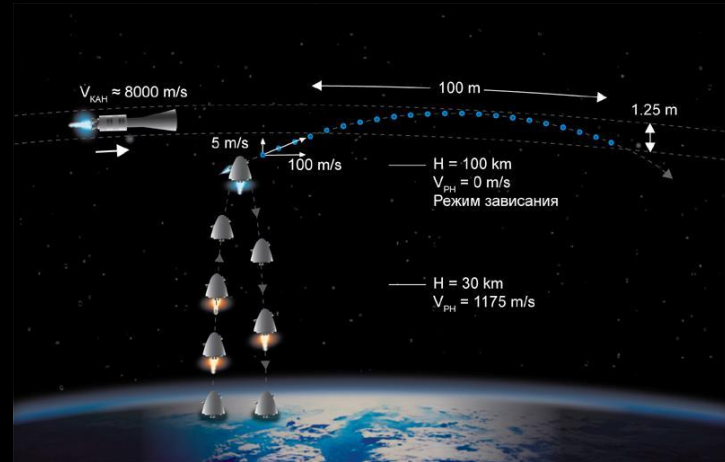
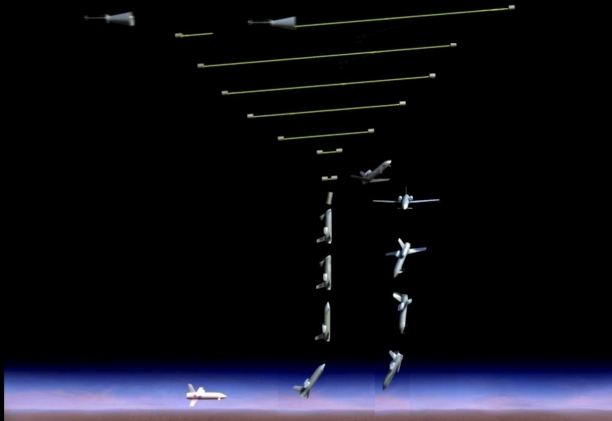
# Orbitron, Orbital Substance Collector (OSC)



- Additional model Orbit-Orbit

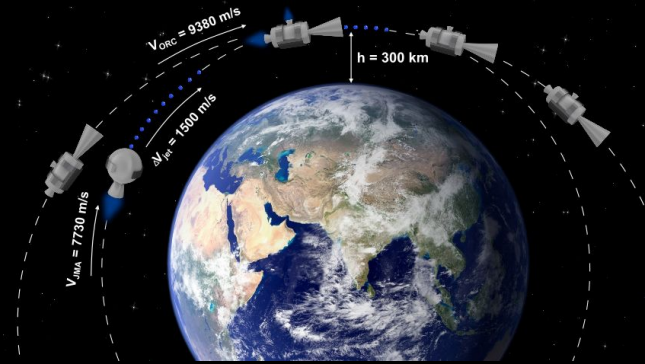
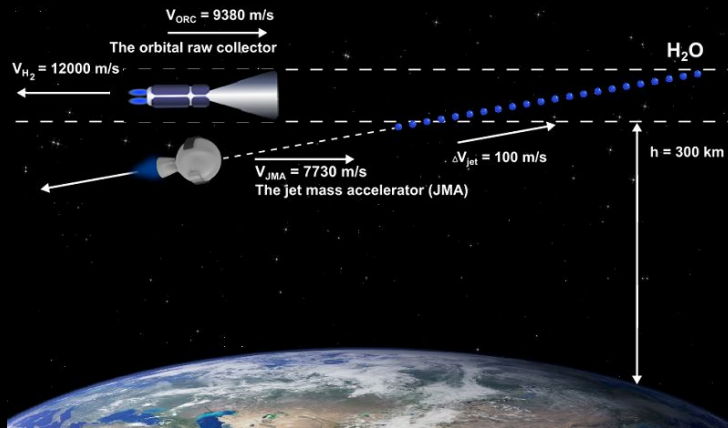


# Earth-Orbit System



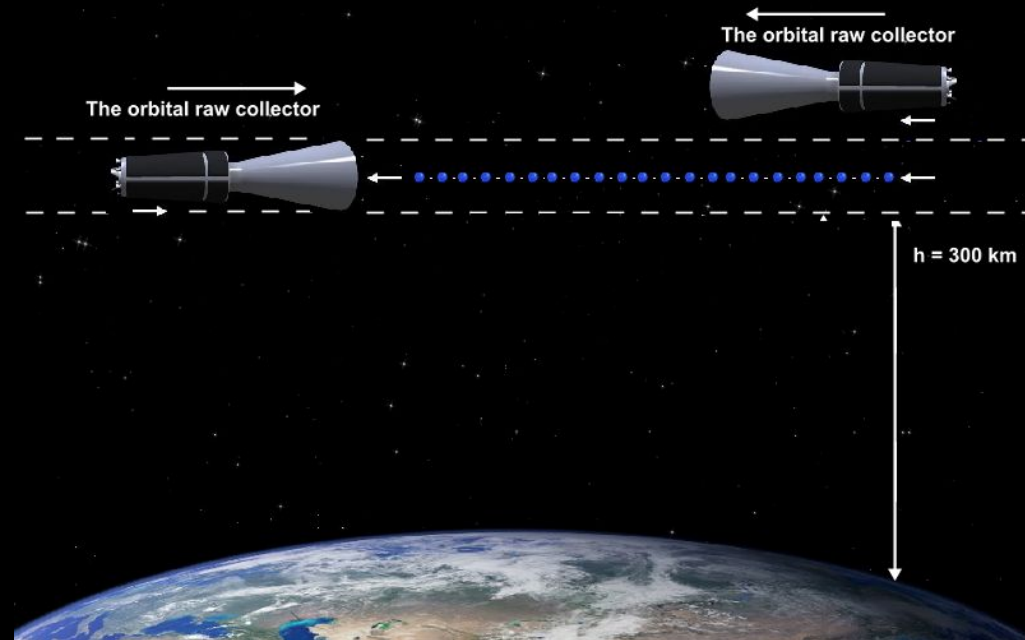
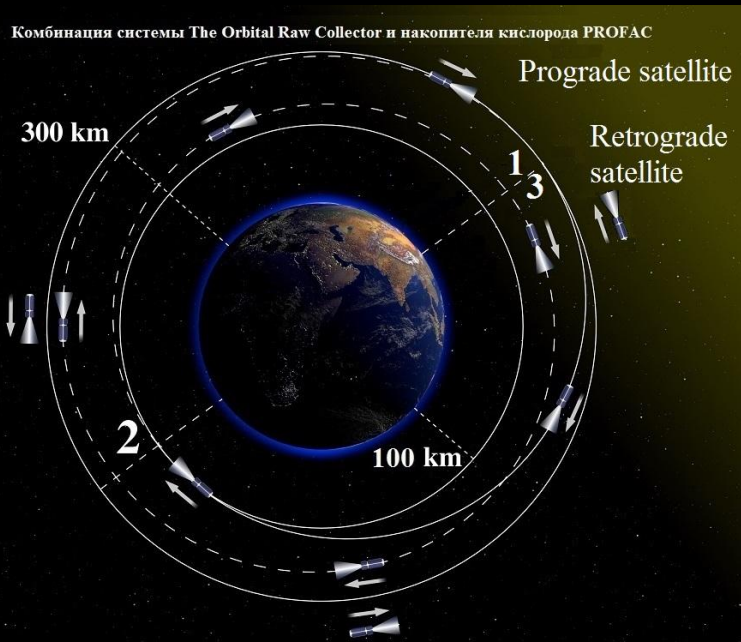
- Basic model of the Earth-Orbit system:  $dV=8\ 000 \text{ m/sec}$ .
- Starting mass of suborbital rocket: 1 000 kg.
- Orbital collector mass: 3 600 kg.
- Electric capacity of the collector: 0.5 MW
- Annual cargo traffic: 29 000 kg.
- Launch pad and reusable space vehicle cost: \$ 2 million per unit.
- Orbital collector cost: \$ 36 million.
- The cost of the set of one collector and two launch pads: \$ 40 million.
- Unit delivery cost: \$ **600** / kg.

# Orbit-Orbit System



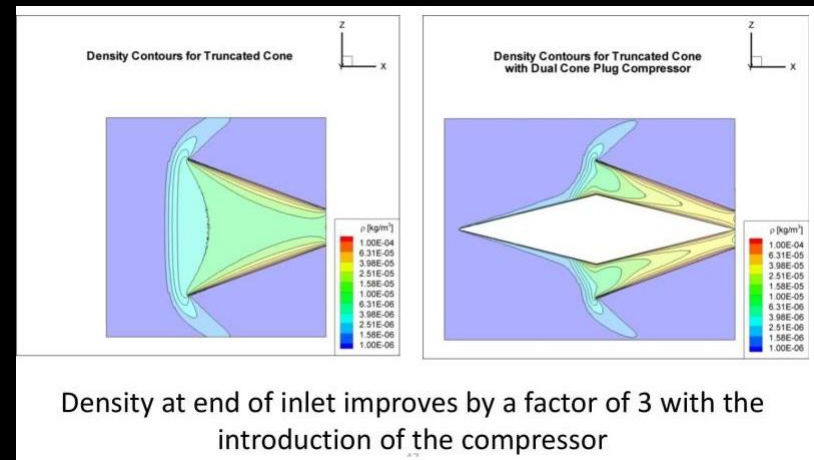
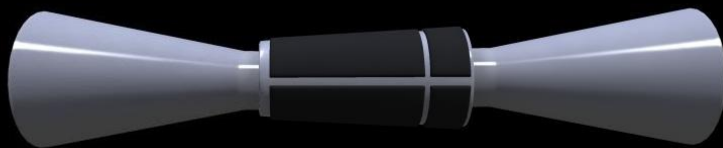
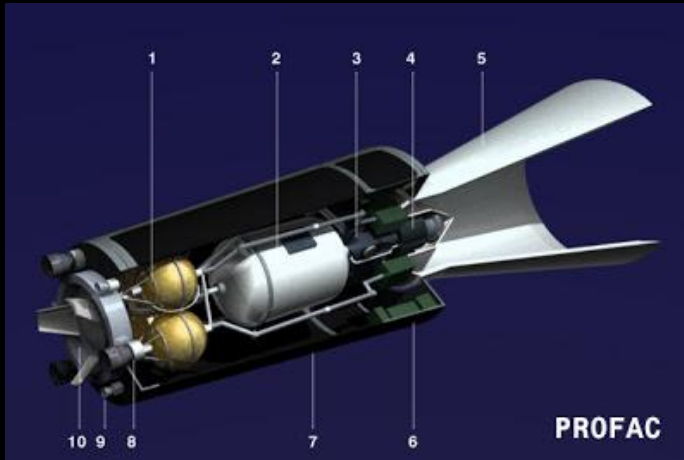
- Additional model of the Orbit-Orbit system:  $dV=2\ 000 \text{ m/sec}$ .
- Orbital collector mass: 1 000 kg.
- Electric capacity of the engine system: 0.01 MW (!)
- Annual cargo traffic: 11 000 kg.
- Orbital collector cost: \$ 10 million.
- Unit delivery cost: \$ **180** / kg plus the cost of delivery to LEO.
- Economic effect: price reduction for delivery from LEO to geotransitional orbit from \$ 10 000 -20 000 to \$ **180** / kg.

# Non-Rocket Atmosphere-Orbit System



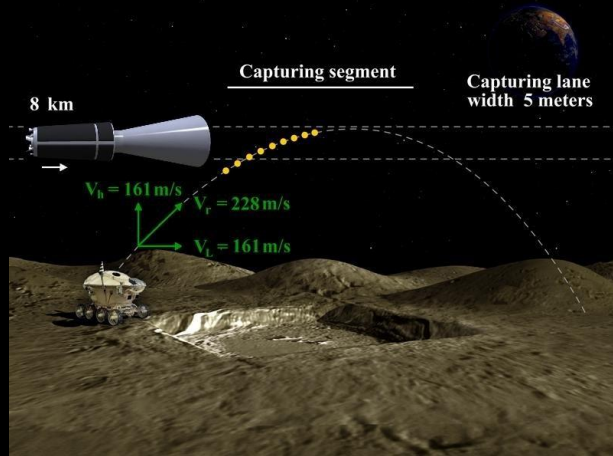
- Two-collector system on prograde and retrograde (reverse) orbits that exchange cargoes for periodic submerging into dense atmosphere.
- Total mass of the two orbital collectors: 3 600 kg.
- Electric capacity of the collector engine unit: 0.5 MW
- Annual cargo traffic: 15 000 kg /year.
- Life cycle: 5 years.
- Orbital collector set cost: \$ 36 million.
- Unit cost to collect atmospheric oxygen and nitrogen: \$ **500** / kg.

# Non-Rocket Atmosphere-Orbit System»



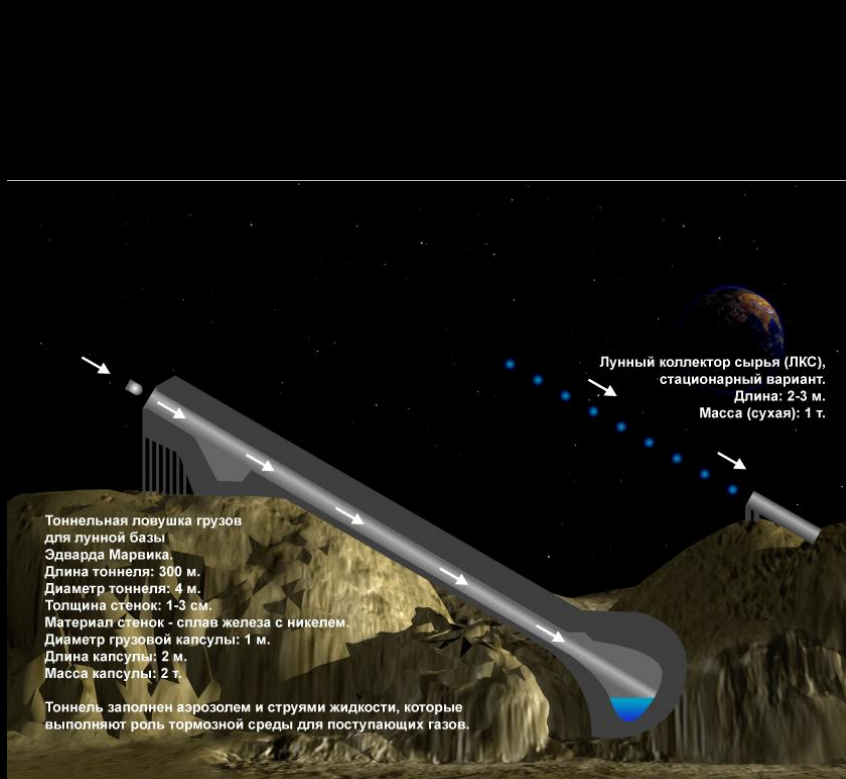


# Moon-Orbit System

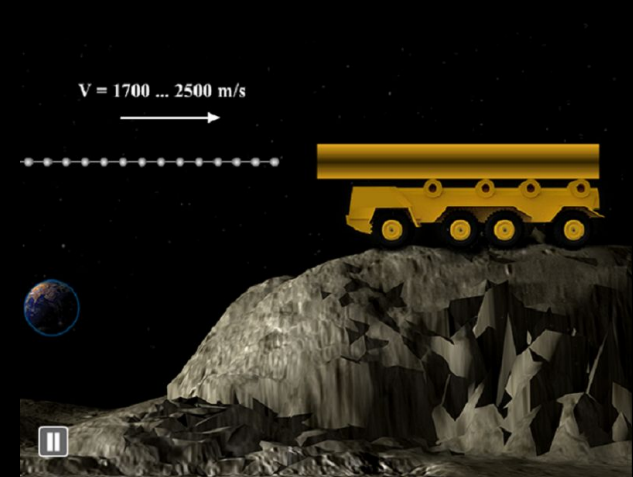
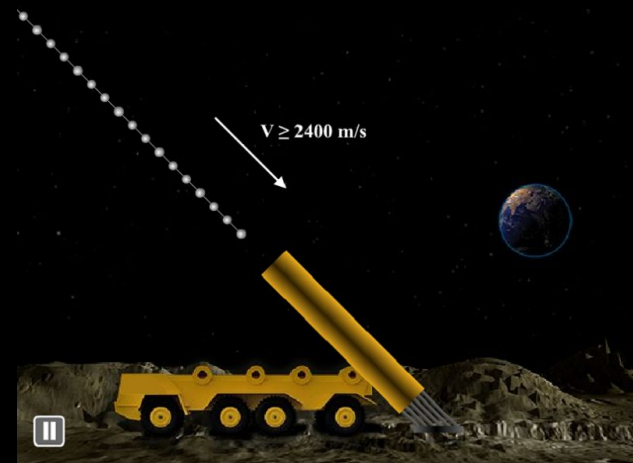


- Basic model of the Moon-Orbit system:  $dV=1\ 680 \text{ m/sec}$ .
- Mechanical catapult mass: 200 kg.
- Orbital collector mass: 1 800 kg.
- Electric capacity of the collector: 0.03 MW
- Magnesium and calcium usage in electric propulsion motor: 1 000 kg / year.
- Annual cargo traffic: 29 000 kg /year (3 000 captures by 10 kg portion).
- Launcher cost: \$ 20 million per unit.
- Orbital collector cost: \$ 90 million.
- The cost of the set of one collector and two launch pads and two catapults: \$ 130 million.
- Unit delivery cost: \$ **900** / kg.

# Orbit-Moon System

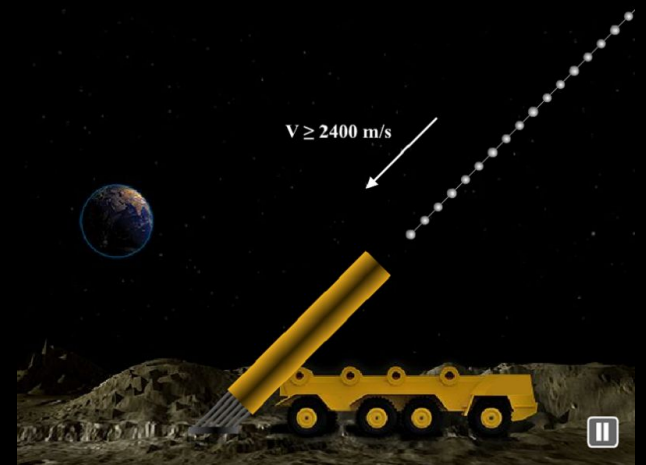
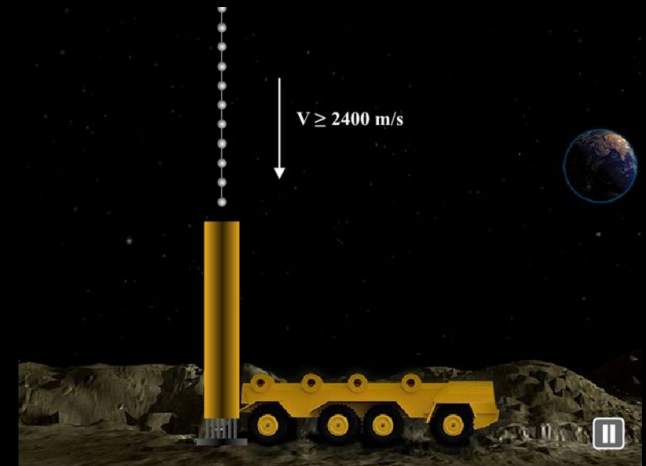


Mass-dimensions characteristics of American prototype and the new developed moon collector for high-speed substance flows.

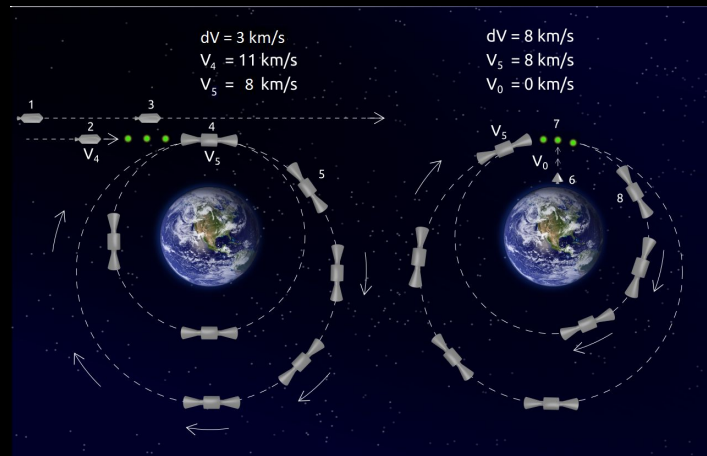
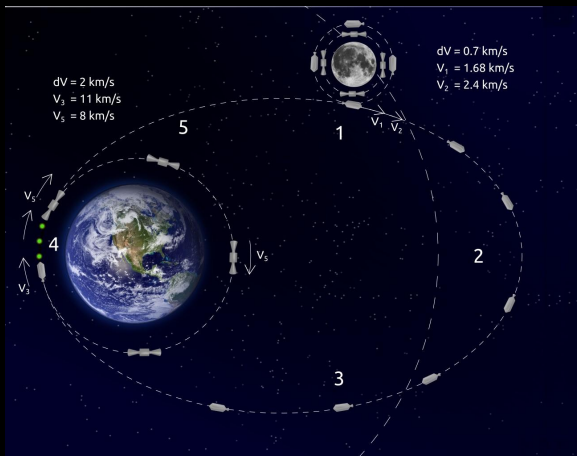
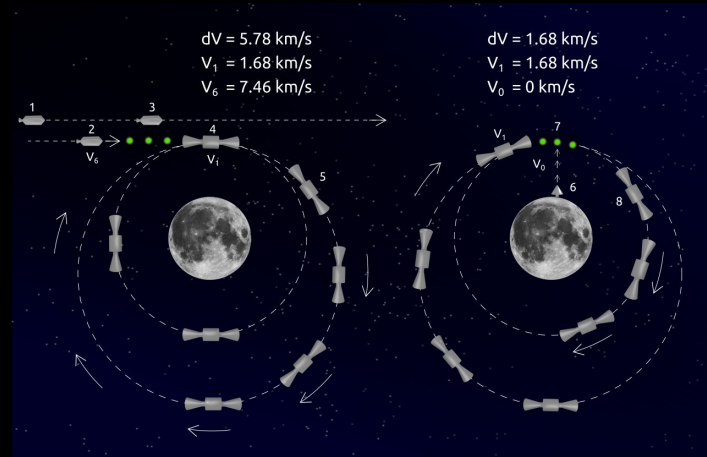
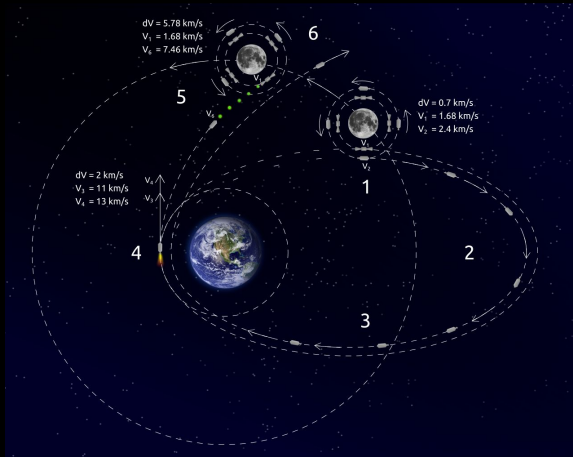


# Orbit-Moon System

- Absorbed substance flow speed:  
 $dV=1680\dots3000$  m/sec.
- Substance flow forms: Mylar bands coated with solid substances and kapton tubes with liquid substances.
- Absorbed cargoes: carbon, hydrogen, nitrogen, chlorine, fluoride, oxygen, potassium, aluminum compounds, etc.
- Per-second substance inflow: 10 kg / sec.
- Collector working resource: about 3 hours (10 000 seconds).
- Dry mass of the stationary collector – 1 000 kg.
- Cargo mass intake throughout the life cycle – 100 000 kg (10 000 captures by portions of 10 kg each).
- Cost of stationary collector: \$ 10 million.
- Unit cost to deliver cargoes: \$ 1 000 / kg
- Economic efficiency: price reduction for delivery from low lunar orbit to the Moon surface from \$20 000 – 50 000 / kg to \$ 1 000 / kg.
- When earth hydrogen is used to produce regolith rocket fuel, its cost at the base will be **\$6000 / kg** (excluding the cost of technical blocks' depreciation & amortization).



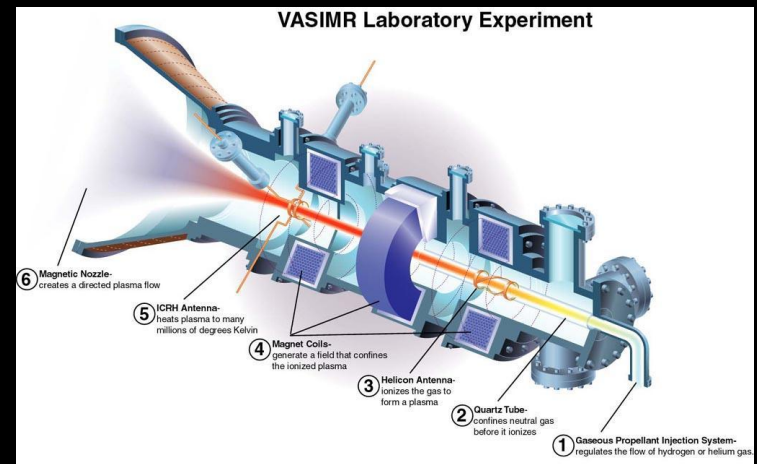
# Moon-Earth System



- Orbitron Moon and Earth joined systems use potential and kinetic energy stocks of the Earth and the Moon. The energy is produced by active gravitation maneuver (Oberth effect).

# Resources for Suborbital Subsystem and Orbital Collector

- Suborbital rockets, alternatively to space rockets, survive the first launch and are reusable for 200-1 000 launches.
- In the project we use the solution that allows reusing suborbital rockets from 1 000 to 6 000 launches: temperature in combustion chamber does not exceed 1 250 K.
- The orbital collector engines of NEXT or VASIMR type possess long life cycle of about 50 000 hours or 5.5 years.



# Resources for Suborbital Subsystem and Orbital Collector

- Heat protection of rocket stages excluding its first stage is executed similar to that of X-20 Dyna-Soar rocketplane with radiative cooling made of refractory metals and alloys (molybdenum, zirconium, rhenium-niobium alloy Rene 41) without ablation or heat-absorbing ceramic coating.
- This type of heat protection ensures minimal time for its routine maintenance after the landing of suborbital rocket and its long life cycle.
- Due to the extended repair interval for heat protection and the engine, the launch frequency for the suborbital rocket is from four to eight launches per day.



# Resources for Suborbital Subsystem and Orbital Collector



- Analogue to the Bullet Catcher orbital collector.
- Bullet traps do not deform bullets:  $dV$  up to 1100 m/sec; Kevlar deceleration environment resource is 10 000 shots.
- Bullet traps of solid deceleration are filled with water/sand and prove to have practically unlimited life cycle; their  $dV$  lies between 8 000 and 11 000 m/sec.
- To prevent emergency collisions Armour Screen is used; it is made of such materials the sound speed of which is between 13 000 and 18 000 m/c.
- The 3D printer on board compensates Armour Screen erosion.

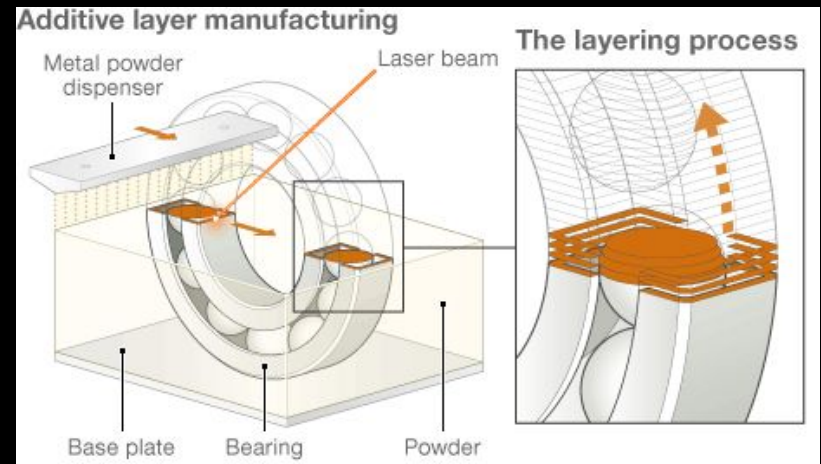
# Types of Cargoes



- The collector can receive cargoes of only raw material type that are not destroyed by impact acceleration.
- However, most cargoes delivered into space are not spacecraft but rocket fuel to set them into the final orbit.
- Up to 80% of the spacecraft's weigh is the mass of its fuel. Therefore, the proposed space vehicle system will have many types of cargoes.



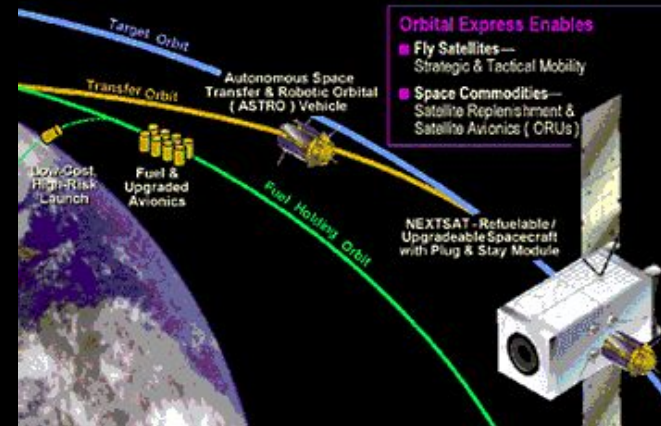
# Types of Cargoes



- In addition to fuel, such substances as aluminum, titanium, carbon, silicon and other necessary substances are to be transported into space to produce spare parts and units for spacecraft in the framework of AMAZE program.
- European Space Agency (ESA) has launched AMAZE program to apply 3D printing technology for production of metallic parts and units for spacecraft, airplanes and thermonuclear reactors;
- ESA has invested about € 20 million into R&D to create AMAZE 3D Printing Technology.

# Orbitron Technology Business Opportunities

- The technology implementation allows its users to create:
- A chain of space fueling stations to fuel inter-orbital boosters and tugs;
- A chain of orbital platforms with 3D printers to produce spare parts and units for spacecraft.



# Patents



- Method and system for delivering cargoes into space. US 8882047 B2.  
Status: Grant of patent is intended
- Method for delivering cargoes into space and a system for implementation of same. EP2390188  
Status: Grant of patent is intended (Great Britain, Germany, France).
- Способ доставки грузов в космос и система его осуществления. Patent of Russia RU2398717
- Способ доставки грузов в космос и система его осуществления. Patent of Eurasia Patent Organization 017577
- Спосіб доставки вантажів в космос і система його здійснення. Patent of the Ukraine 99230
- Способ энергообеспечения космических аппаратов-накопителей. Patent of Russia RU2451631
- Energy supply method for spacecrafts-accumulators. Patent application pending US 2013/0233974 A1
- Method and system for feeding jet engines. Patent application pending US 2014/0326832 A1

# Patents



Patentamt  
European  
Patent Office  
Office européen  
des brevets

**URKUNDE**

Es wird hiermit bescheinigt, dass für die in der Patentschrift beschriebene Erfindung ein europäisches Patent für die in der Patentschrift bezeichneten Vertragsstaaten erteilt worden ist.

**CERTIFICATE**

It is hereby certified that a European patent has been granted in respect of the invention described in the patent specification for the Contracting States designated in the specification.

**CERTIFICAT**

Il est certifié qu'un brevet européen a été délivré pour l'invention décrite dans le fascicule de brevet, pour les Etats contractants désignés dans le fascicule de brevet.

Europäisches Patent Nr.	European patent No.	Brevet européen n°
	2390188	
Patentinhaber	Proprietor of the patent	Titulaire du brevet
<p style="text-align: center;">Maiboroda, Alexander Olegovich S Rostov-na-Donu 344006/RU</p>		


  
  

München, den  
Munich,  
Fait à Munich, le

18.06.14



Benoit Battistelli  
Präsident des Europäischen Patentamts  
President of the European Patent Office  
Président de l'Office européen des brevets



US00882047B2

**(12) United States Patent**  
**Maiboroda**

**(10) Patent No.: US 8,882,047 B2**  
**(45) Date of Patent: Nov. 11, 2014**

(54) **METHOD AND SYSTEM FOR DELIVERING CARGOES INTO SPACE**

(76) **Inventor:** Alexander Olegovich Maiboroda, Rostov-na-Donu (RU)

(\* ) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 289 days.

(21) **Appl. No.:** 13/144,275

(22) **PCT Filed:** Feb. 2, 2010

(86) **PCT No.:** PCT/RU2010/000036

§ 371 (e)(1), (2), (4) **Date:** Jul. 12, 2011

(87) **PCT Pub. No.:** WO2010/082869  
**PCT Pub. Date:** Jul. 22, 2010

(65) **Prior Publication Data**  
US 2011/0272528 A1 Nov. 10, 2011

(30) **Foreign Application Priority Data**  
Jan. 13, 2009 (RU) ..... 2009100935

(51) **Int. Cl.**  
*B64G 1/10* (2006.01)  
*B64G 1/40* (2006.01)  
*B64G 1/00* (2006.01)  
*B64G 1/64* (2006.01)

(52) **U.S. Cl.**  
CPC ..... *B64G 1/078* (2013.01); *B64G 1/002* (2013.01); *B64G 1/40* (2013.01); *B64G 1/648* (2013.01)  
USPC ..... 244/158.5; 244/171.1; 244/172.2; 244/172.4

(58) **Field of Classification Search**  
CPC ..... B64G 1/10; B64G 1/085; B64G 1/0789; B64G 1/409  
USPC ..... 244/158.1, 158.2, 158.5, 171.1, 172.2, 244/172.4, 172.7  
See application file for complete search history.

(56) **References Cited**  
U.S. PATENT DOCUMENTS  
3,818,700 A \* 6/1974 Kasrowitz et al. .... 244/74  
4,753,120 A 10/1988 Marwick  
5,224,563 A \* 7/1990 Criswell ..... 244/1 R  
8,251,315 B2 \* 8/2012 Loya ..... 244/158.4

**OTHER PUBLICATIONS**  
A. Slibanov "The Concerns of a Space Architect"—M.: Detskaya Literatura, 1982, p. 15-39. Attention, Energy Overboard! (Extract and English translation of Extract enclosed)  
Andreev, A.V. "Some Issues on Lunar Substance Transportation" Proceedings from Readings XIX by K. E. Tsolokovskiy Section "The Problems of Rocket and Space Engineering".—M.: IET, An USSR, 1986, p. 87-96; (Extract and English translation of Extract enclosed)

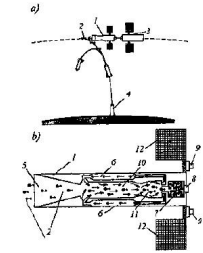
(Continued)

*Primary Examiner* — Rob Swiatek  
(74) *Attorney, Agent, or Firm* — Voipe and Koenig, P.C.

(57) **ABSTRACT**  
A method and respective system for delivering cargoes into space by means of preliminary launching cargoes and then capturing cargoes by at least one container spacecraft, accumulating and further transferring to other spacecrafts, wherein the container spacecraft is designed for capturing cargoes as separate portions in the form of a cloud or stream as well as for use of a propulsion system to compensate for container spacecraft speed losses caused by the cargo capture and an aerodynamic drag, wherein the propulsion system being a reactive type with consumption of a part of the incoming cargoes as a working substance.

**5 Claims, 1 Drawing Sheet**



# Sales and Marketing

## 1. Запуски геостационарных коммерческих спутников связи и вещания в 2001-2013 годах

### 1.1. Общие сведения об успешно запущенных на орбиту геостационарных коммерческих спутниках связи и вещания.

В конце 2013 года в космосе выполняли целевую задачу 1181 КА различного назначения [1].

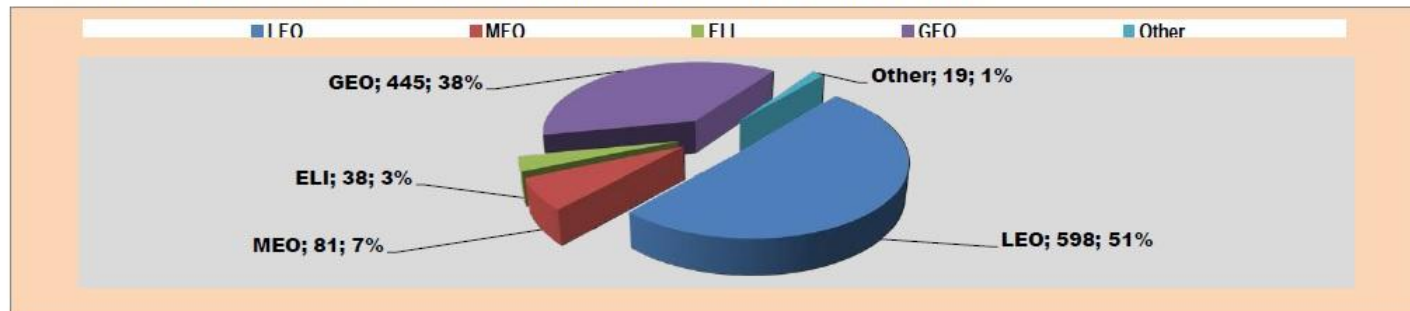


Диаграмма 1.1. Распределение спутников по состоянию на 31.12.2013 года по типам орбит (источник: *Union of Concerned Scientists, UCS*).

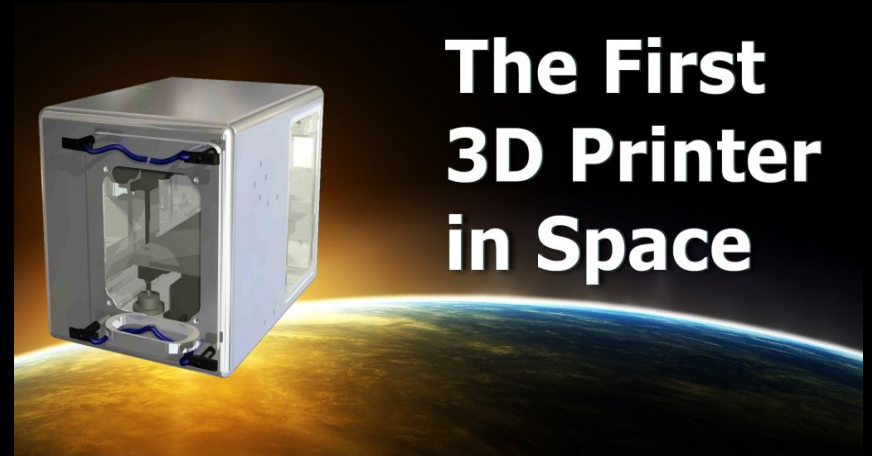
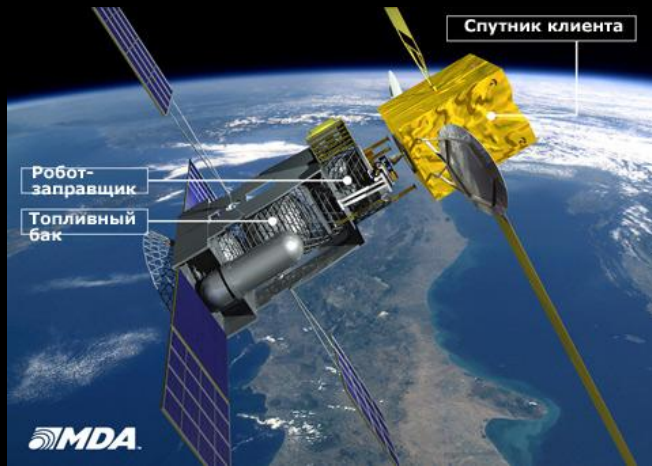


Диаграмма 1.2. Распределение спутников по состоянию на 31.12.2013 года по странам (источник: *Union of Concerned Scientists, UCS*).

# Sales and Marketing

- Estimated revenue for licensees and franchisees when trading the following goods (in USD per year):
  - Rocket fuel of 300 tons: \$0.9 billion/year;
  - Technological materials of 100 tons: \$0.3 billion/year;
  - Semiconductors of 400 tons: \$1.2 billion/year.
- Investors' Revenue:
  - License vending in the USA, EU and Russia;
  - Franchising in “space club” countries;
  - Royalties;
  - Founder's profit when a joint stock company is created after seed investment stage is over.

# Market segments



## The First 3D Printer in Space

- Launch Services market: \$ 5 billion / year;
- Spacecraft and satellites production market, spacecraft being produced on the orbit using AMAZE program: \$16 billion/year

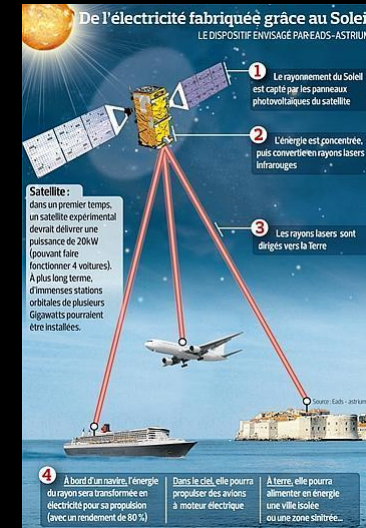
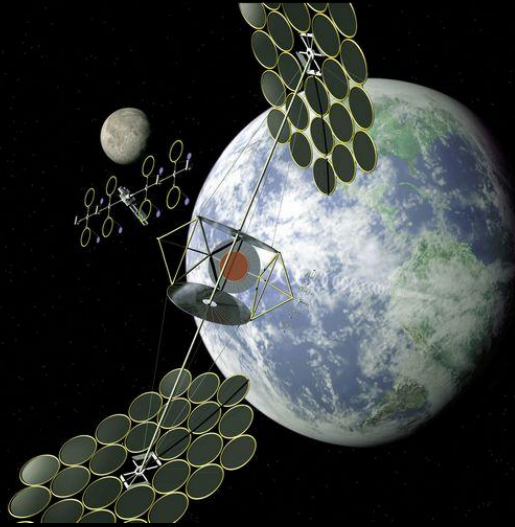
# Market segments



- Photoelectric converters market:  
\$ 100 billion / year;
- Including thin-film solar batteries:  
\$25 billion / year.

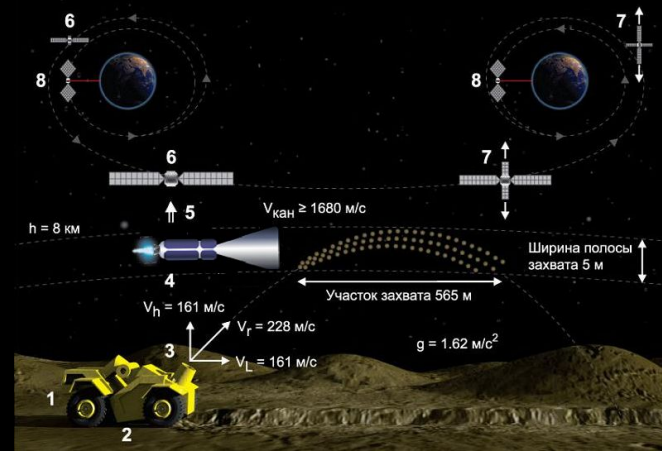
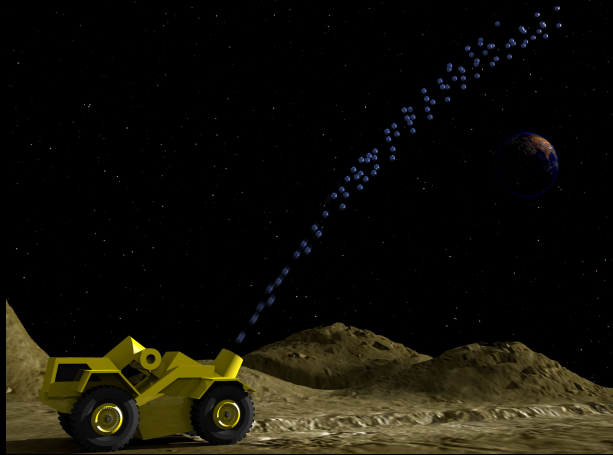


# Market segments



- Raw material supply market for satellite solar power station construction in the framework of the Japanese Solarbird program: \$24 billion.

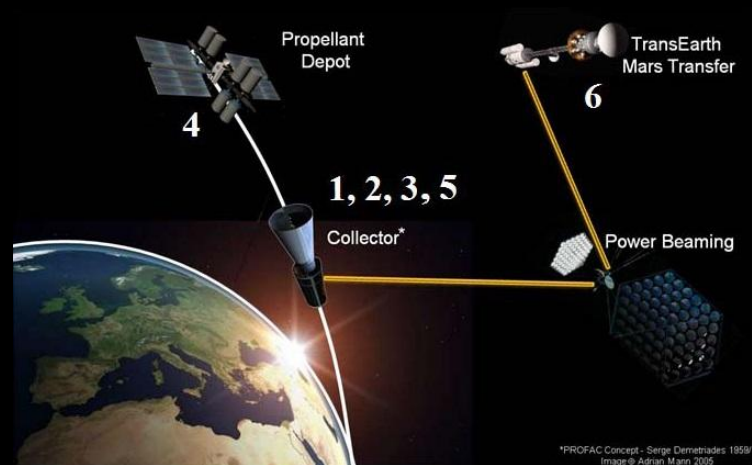
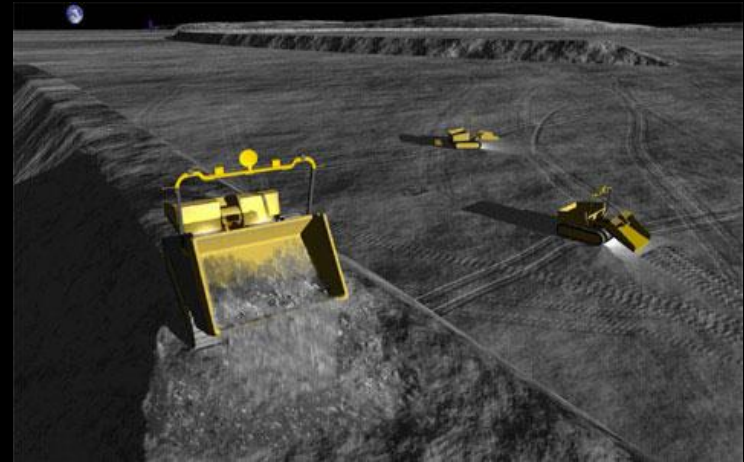
# Market segments



- Material delivery market to construct and maintain Lunar Base in the framework of the Russian program (patents granted until 2030):
- Construction: \$ 40 billion
- Supplies to the base: \$ 4-15 billion / year.

# Competitors

- Shackleton Energy Company, USA, working on water-production technologies on the Moon to produce oxygen and hydrogen to sell them via orbital fueling stations.
- PHARO start-up, USA, developing PROFAC system with laser energy drive to collect atmospheric oxygen in order to produce fuel for space fueling stations.



# Potential Partners

- Planetary Resources
- Deep Space Industries
- SpaceX
- Bigelow Aerospace
- Boeing Company
- EADS Astrium
- MDA
- Mitsubishi Corp.
- Shimizu Corp.
- TSNIIMASH (Central Scientific Research Institute of Machine Building): orbital space vehicle air collectors and frameless solar batteries
- Institute for Space Research of the Academy of Sciences: Spacecraft mathematic models
- United Institute a High Temperatures: Mathematic models for shock and impact processes



# Potential Partners

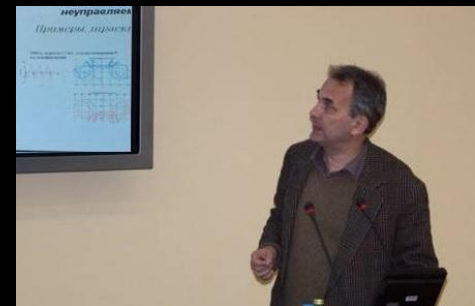


- Institute of Semiconductor Physics of Siberian Department of Russian Academy of Sciences and Russian Space Agency: OKA-T technological module
- Moscow State Technical University named after N.E. Bauman: EDTS cable electric engine
- State Space Research and Production Center named after M. Khrunichev: MRKC-1 suborbital demonstrator
- Design Engineering Department for Chemical Automation: YARD Thermal-chemical simulator /Nuclear thermal rocket /
- State Scientific Center named after Keldysh: heating exchange hydrogen engine unit for solar heat rocket engine
- Lin Industrial Company: suborbital mini launch rockets

# Team

- Ideal of the Project: Alexander Mayboroda
- Project Manager: Vladimir Megel
- Leading Specialists:  
D.K. Dragun, V.M. Melnikov, O.P. Pchelyakov, V.I. Florov
- Main participants and their skills: the team has ten specialists with necessary qualifications, knowledge and experience. Among them, there are specialists of TSNIIMASH, Vympel Design Engineering Department, Moscow State Technical University named after N.E. Bauman, Institute for Space Research of the Academy of Sciences, Institute of Semiconductor Physics of Siberian Department of Russian Academy of Sciences, Sputniks Company.

# Team



# R&D First Stage Investment

- Stages of the working process:
  - Conceptual Design Studies;
  - Computer Simulation of the Processes;
  - Collector Demo Model Creation, its bed testing, follow-up revision;
  - Production of collector in micro-satellite version for orbital tests ( $dV=1400-2000$  m/sec), follow-up revision;
  - Resources required: 40 million rubles (including 10 million rubles from a private investor and 30 million rubles from Scolkovo Fund)
  - First stage lasts for two years.
- 
- Keeping the US and EU patents and completion of new patents obtaining process require:
  - \$ 11 000 in 2015;
  - \$ 5 000 in 2016.



# Summary and Contacts

- The developed system ensures radical cost decrease for space cargoes delivery.
- Cost efficiency provides extra profit in the sphere of raw material space cargoes delivery to orbital spacecraft.
- We are looking for commercial partners and investors to continue the project.
- AVANTA Consulting welcomes you to collaborate in commercialization of Orbitron Project.
- Address: 150 Bolshaya Sadovaya Street, suite 909, Rostov-on-Don, 344000, Russia.
- Ph.: +7 (863) 221 73 71; +7 (863) 263 32 94
- Email: [mayboro@gmail.com](mailto:mayboro@gmail.com)  
URL: [www.mayboroda.com](http://www.mayboroda.com)

Thank you for your attention  
Your questions are welcome

**«ОРБИТРОН» - КОСМИЧЕСКАЯ ТРАНСПОРТНАЯ СИСТЕМА МНОГОКРАТНОГО ПРИМЕНЕНИЯ**

Обеспечивает доставку грузов в космос за счет электроракетных двигателей малой тяги.  
 На каждый 1 Ньютон тяги ЭРД за 1 год работы доставляет на орбиту 4 тонны грузов.  
 Состоит из космической системы в виде орбитального КА-коллектора и аэрокосмической на основе суборбитальных ракет многократного применения.  
 Удельная себестоимость составляет 5-10% нынешних затрат.



**ОРБИТАЛЬНЫЙ КОЛЛЕКТОР ВЕЩЕСТВА ОКВП-10**

Ресурс системы – 48 тыс. часов (5,5 лет). Грузопоток с Земли в космос – до 58 тонн/год.

Выводимые грузы – компоненты ракетного топлива, технологические и конструкционные материалы. Масса коллектора – 3,6 тонн. Апогейная высота – 320 км. Высота перигейная – 245 км.



**МНОГОРАЗОВАЯ СУБОРБИТАЛЬНАЯ РАКЕТА MCR-10**

Стартовая масса – 1000 кг.  
 Масса полезной нагрузки – 10 кг.  
 Трехступенчатая конструкция.  
 Материал корпуса из сплавов типа «Инконель 718» и кобальтовых сплавов.  
 Вытеснительная система подачи топлива.  
 ЖРД «холодного» типа, с температурой в камере сгорания ниже 1250 К.  
 Рабочий ресурс ЖРД – 1000 часов.  
 Назначенный ресурс MCR – 6000 пусков и посадок.  
 Частота запусков – до 8 запусков/сутки.

**Топливо:**  
 1. Мотоптопливо на основе гидразина (MCR-10M).  
 2. Бинарное топливо на основе кислорода и метана или пероксида водорода и пропана/бутана (MCR-10B).

**Полезный груз:**  
 1. майларовые ленты с покрытием из транспортируемых веществ (магний, алюминий, титан, углерод, кремний и т.п.).  
 2. картонные трубки с криогенной жидкостью (водород, кислород, метан, аргон и т.п.)

Стоимость орбитального коллектора – 36 млн. Долл.  
 Стоимость суборбитальной ракеты MCR-10 – 1 млн. долл.  
 Стоимость пусковой установки – 1 млн. долл.  
 Стоимость комплекса (1 коллектор, 2 МРС, 2 пусковые установки) – 40 млн. долл.  
 Удельная себестоимость доставки грузов в космос – 600 долл./кг.

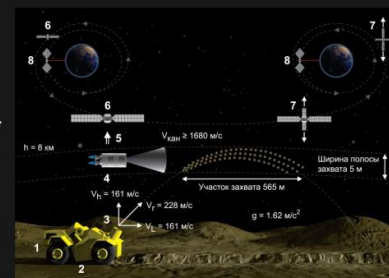


**КТС «ОРБИТРОН» - ОСНОВА ИНДУСТРИАЛИЗАЦИИ КОСМОСА**

Проект направлен на радикальное снижение стоимости доставки топливных и конструкционно-технологических материалов на орбитальные КА в целях снабжения топливом орбитальных АЗС и сырьем космических платформ с 3D принтерами.

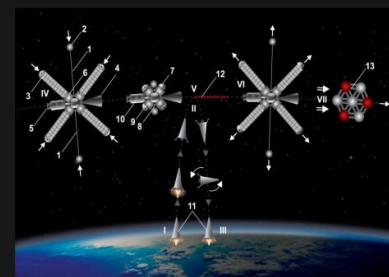
**Производство солнечных батарей на базе лунных ресурсов**

Сырье подается в орбитальный коллектор без использования ракет, что сокращает затраты и обеспечивает большой ресурс работы системы. Около 10% сырья используется в ЭРД коллектора как рабочее тело. Это извлекаемые из ролита магний и кальций. До 90% сырья сохранится для переработки.



**Околоземный аппарат-коллектор**

Сырье подается в орбитальный коллектор без использования ракет космического назначения. Применение суборбитальных ракет увеличивает ресурс аэрокосмической части системы до 1000 часов – суборбитальные ракеты используются многократно до 6000 запусков. Благодаря системе сублимации и разветвления солнечных батарей, коллектор на низкой высоте вместо ядерного реактора использует солнечные батареи. Рабочий ресурс ЭРД коллектора 50 тыс. часов. В итоге обеспечиваются низкие затраты на индустриализацию космоса.



**Изготовление теплозащитных экранов для орбитальных многоразовых ступеней РН космического назначения**

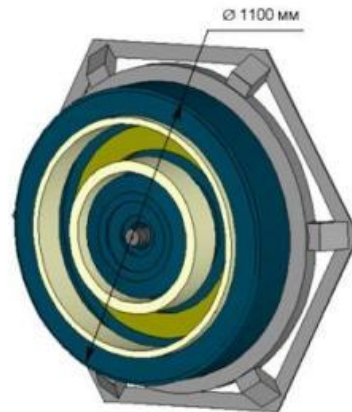
Потоки недорогого сырья в орбитальные КА по цене 100-600 долл. позволяют решить проблему многоразовых РН. Теперь теплозащитные оболочки для возвращения РН формируются на орбитальной станции, что освобождает РН при старте с Земли от бремени тепловой защиты и обеспечивает снижение стоимости запусков.



# Appendix

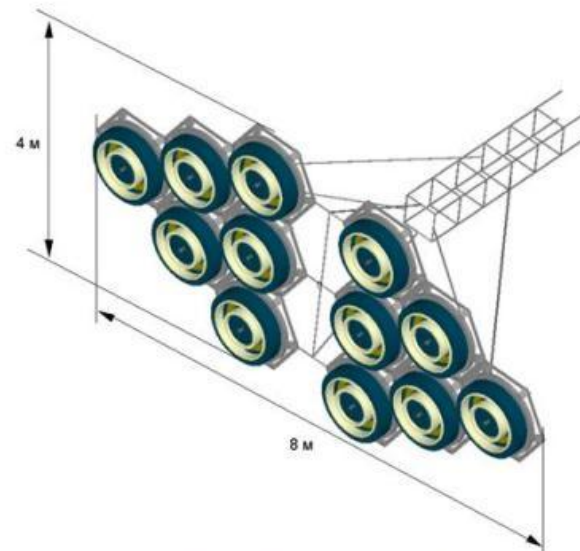


## ПРОЕКТ ЭРДУ МОЩНОСТЬЮ 1 МВт НА БАЗЕ ХОЛЛОВСКИХ ЭРД



Проектные параметры  
единичного модуля СПД

Мощность, кВт	100		
Напряжение разряда, В	200	250	300
Ток разряда, А	490	392	327
Тяга, кгс	0,87	0,78	0,71
Расход ксенона, мг/с	635	508	423
Удельный импульс, с	1400	1565	1700
КПД, %	60		



Проектные параметры ЭРДУ на  
базе 10 основных и 2 резервных  
модулей СПД

Мощность	1 МВт
Тяга	7 - 9 кгс
Удельный импульс	1400 – 1700 с

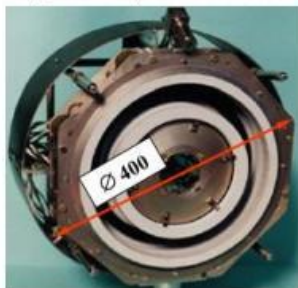
# Appendix



## ХОЛЛОВСКИЕ И ИОННЫЕ ЭРД ВЫСОКОЙ МОЩНОСТИ



*ХД М290 (ОКБ «Факел»)*



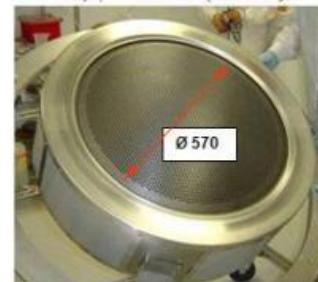
Мощность 30 кВт  
Удельный импульс 3200 сек

*ХД NASA-457M (США)*



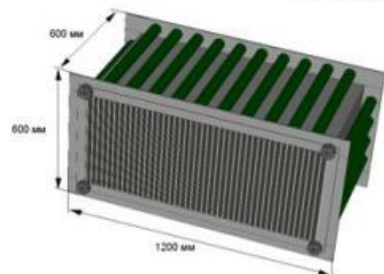
Мощность до 70 кВт  
Удельный импульс 3250 сек

*ИД NEXIS (США)*

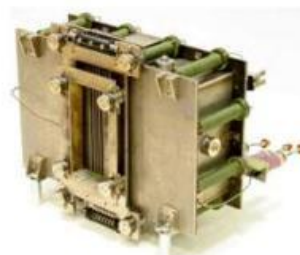


Мощность до 20 кВт  
Удельный импульс 7000 сек

### *Работы по проекту ЭРД-50 (Центр Келдыша)*



Мощность 30 кВт  
Удельный импульс 7000 сек



ИД-180П: Мощность 2 кВт  
Удельный импульс 7000 сек



# Appendix



# Appendix

