Provisional Patent Application

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SPECIFICATION

INVENTION TITLE

Method and Installation for Cleaning the Outer Space from Space Debris

CROSS-REFERENCE TO RELATED APPLICATIONS

None

USA PTO disclosure document No. _______

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

REFERANCE TO A "SEQUENCE LISTING"

Not Applicable

REFERENCE TO A MICROFICHE APPENDIX

Not Applicable

DESCRIPTION

BACKGROUND OF THE INVENTION

Field of the invention

Currently (2011), about 19,000 pieces of space debris larger than 5 cm (2.0 in) are tracked (for example: old non-working satellites, last stages of rockets and so on). Any of them can catastrophic damage the working space apparatus, space stations and space ship. The field of invention is a method and installation (space apparatus) for cleaning the outer Space from Space debris, protection current and future space station, ships, space apparatus from space debris, meteroids and enemy attack. Offered devices also can be installed on new space apparatus for returning them into the planet atmosphere after lifetime or in dangerous situation.

Author offers new method and installation for cleaning the outer space from space debris and individual protection the important space ship and stations from big space debris (SD). Advantages of the offered method and apparatus are following: 1. Less size and weight in 2 -3 times than conventional SD Collector. 2. More efficiency in 2 -10 times. 3. Save fuel in some times. 4. No limits in size for SD. 5. Can easy protect selected space ship and station (for example, International Space Station) from SD.

Current U.S. Class: **244/158.1** ; 244/158.3; 244/158.6; 244/158.7

Current International Class: B64G 1/00 (20060101); B64G 1/10 (20060101)

Field of Search: Space Debris and Space Cleaner.

Description of the related art

Short Review of Debris Problem

Satellites.

The world's first artificial satellite, the Sputnik 1, was launched by the USSR in 1957. Since then, thousands of satellites have been launched into orbit around the Earth. Artificial satellites originate from more than 50 countries and have used the satellite launching capabilities of ten nations. A few hundred satellites are currently operational, whereas thousands of unused satellites and rocket fragments orbit the Earth as space debris.

About 6,600 satellites have been launched. The latest estimates are that 3,600 remain in orbit. Of those, about 1000 are operational; the rest have lived out their useful lives and are part of the space debris. Approximately 500 operational satellites are in low-Earth orbit, 50 are in medium-Earth orbit (at 20,000 km), the rest are in geostationary orbit (at 36,000 km).

When satellites reach the end of their mission, satellite operators have the option of de-orbiting the satellite, leaving the satellite in its current orbit or moving the satellite to a graveyard orbit. As of 2002, the FCC requires all geostationary satellites to commit to moving to a graveyard orbit at the end of their operational life prior to launch.

Space Debris.

Space debris, also known as orbital debris, space junk, and space waste, is the collection of defunct objects in orbit around Earth. This includes everything from spent rocket stages, old satellites, fragments from disintegration, erosion, and collisions. Since orbits overlap with new spacecraft, debris may collide with operational spacecraft.

Currently, about 19,000 pieces of debris larger than 5 cm (2.0 in) are tracked, with another 300,000 pieces smaller than 1 cm below 2000 km altitude. For comparison, the International Space Station orbits in the 300–400 km range and both the 2009 collision and 2007 antisat test events occurred at between 800 and 900 km.

Most space debris is less than 1 cm (0.39 in), including dust from solid rocket motors, surface degradation products such as paint flakes, and coolant released by RORSAT nuclear-powered satellites. Impacts of these particles cause erosive damage, similar to sandblasting. Damage can be reduced with "Whipple shield", which, for example, protects some parts of the International Space Station. However, not all parts of a spacecraft may be protected in this manner, e.g. solar panels and optical devices (such as telescopes, or star trackers), and these components are subject to constant wear by debris and micrometeoroids. The flux of space debris is greater than meteroids below 2000 km altitude for most sizes circa 2012.

Safety from debris over 10 cm (3.9 in) comes from maneuvering a spacecraft to avoid a collision. If a collision occurs, resulting fragments over 1 kg (2.2 lb) can become an additional collision risk.

Total mass of space debris is about 5000 tons (2009).

As the chance of collision is influenced by the number of objects in space, there is a critical density where the creation of new debris is theorized to occur faster than the various natural forces remove them. Beyond this point, a runaway chain reaction may occur that pulverizes everything in orbit, including functioning satellites. Called the "Kessler syndrome", there is debate if the critical density has already been reached in certain orbital bands.

Through the 1980s, the US Air Force ran an experimental program to determine what would happen if debris collided with satellites or other debris. The study demonstrated that the process was entirely unlike the micrometeor case, and that many large chunks of debris would be created that would themselves be a collisional threat. This leads to a worrying possibility - instead of the density of debris being a measure of the number of items launched into orbit, it was that number plus any new debris caused when they collided. If the new debris did not decay from orbit before impacting another object, the number of debris items would continue to grow even if there were no new launches.

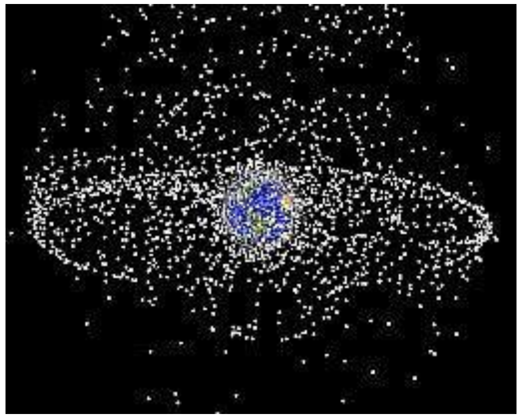
Measurement, growth mitigation and active removal of space debris are activities within the space industry today.

The USAF's conclusions about the creation of debris. Although the vast majority of debris objects by number was lightweight, like paint flecks, the majority of the *mass* was in heavier debris, about 1 kg (2.2 lb) or heavier. This sort of mass would be enough to destroy any spacecraft on impact, creating more objects in the critical mass area. As the National Academy of Sciences put it:

A 1-kg object impacting at 10 km/s, for example, is probably capable of catastrophically breaking up a 1,000-kg spacecraft if it strikes a high-density element in the spacecraft. In such a breakup, numerous fragments larger than 1 kg would be created.

Aggressive space activities without adequate safeguards could significantly shorten the time between collisions and produce an intolerable hazard to future spacecraft. Some of the most environmentally dangerous activities in space include large constellations such as those initially proposed by the Strategic Defense Initiative in the mid-1980s, large structures such as those considered in the late-1970s for building solar power stations in

Earth orbit, and anti-satellite warfare using systems tested by the USSR, the U.S., and China over the past 30 years. Such aggressive activities could set up a situation where a single satellite failure could lead to cascading failures of many satellites in a period of time much shorter than years.



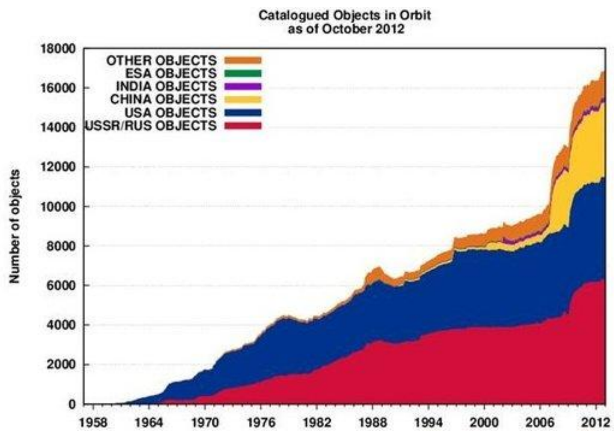
Space debris

Growth of Debris.

Faced with this scenario, as early as the 1980s NASA and other groups within the U.S. attempted to limit the growth of debris. One particularly effective solution was implemented by McDonnell Douglas on the Delta booster, by having the booster move away from their payload and then venting any remaining propellant in the tanks. This eliminated the pressure build-up in the tanks that had caused them to explode in the past.[31] Other countries, however, were not as quick to adopt this sort of measure, and the problem continued to grow throughout the 1980s, especially due to a large number of launches in the Soviet Union.

A new battery of studies followed as NASA, NORAD and others attempted to better understand exactly what the environment was like. Every one of these studies adjusted the number of pieces of debris in this critical mass zone upward. In 1981 when Schefter's article was published it was placed at 5,000 objects, but a new battery of detectors in the Ground-based Electro-Optical Deep Space Surveillance system quickly found new objects within its resolution. By the late 1990s it was thought that the majority of 28,000 launched objects had already decayed and about 8,500 remained in orbit. By 2005 this had been adjusted upward to 13,000 objects, and a 2006 study raised this to 19,000 as a result of an ASAT test and a satellite collision. In 2011, NASA said 22,000 different objects were being tracked.

The growth in object count as a result of these new studies has led to intense debate within the space community on the nature of the problem and earlier dire warnings. Following Kessler's 1991 derivation, and updates from 2001, the LEO environment within the 1,000 km (620 mi) altitude range should now be within the cascading region. However, only one major incident has occurred: the 2009 satellite collision between Iridium 33 and Cosmos 2251. The lack of any obvious cascading in the short term has led to a number of complaints that the original estimates overestimated the issue. Kessler has pointed out that the start of a cascade would not be obvious until the situation was well advanced, which might take years.



Growth of Space Debris.

China produced the space debris — 40 %; USA — 27,5 %; Russia — 25,5 %; the rest country — 7 %. (2009).

A 2006 NASA model suggested that even if no new launches took place, the environment would continue to contain the then-known population until about 2055, at which point it would increase on its own. Richard Crowther of Britain's Defence Evaluation and Research Agency stated that he believes the cascade will begin around 2015. The National Academy of Sciences, summarizing the view among professionals, noted that there was widespread agreement that two bands of LEO space, 900 to 1,000 km (620 mi) and 1,500 km (930 mi) altitudes, were already past the critical density.

In the 2009 European Air and Space Conference, University of Southampton, UK researcher, Hugh Lewis predicted that the threat from space debris would rise 50 percent in the coming decade and quadruple in the next 50 years. Currently more than 13,000 close calls are tracked weekly.

A report in 2011 by the National Research Council in the USA warned NASA that the amount of space debris orbiting the Earth was at critical level. Some computer models revealed that the amount of space debris "has reached a tipping point, with enough currently in orbit to continually collide and create even more debris, raising the risk of spacecraft failures". The report has called for international regulations to limit debris and research into disposing of the debris.

The great majority of debris consists of smaller objects, 1 cm (0.39 in) or less. The mid-2009 update to the NASA debris FAQ places the number of large debris items over 10 cm (3.9 in) at 19,000, between 1 and 10 centimeters (3.9 in) approximately 500,000, and that debris items smaller than 1 cm (0.39 in) exceeds tens of millions. In terms of mass, the vast majority of the overall weight of the debris is concentrated in larger objects, using numbers from 2000, about 1,500 objects weighing more than 100 kg (220 lb) each account for over 98% of the 1,900 tons of debris then known in low earth orbit.

Using the figure of 8,500 known debris items from 2008, the total mass is estimated at 5,500 t(12,100,000 lb).

Sources of space debris.

In a catalog listing known launches up to July 2009, the Union of Concerned Scientists listed 902 operational satellites. This is out of a known population of 19,000 large objects and about 30,000 objects ever launched. Thus, operational satellites represent a small minority of the population of man-made objects in space. The rest are, by definition, debris.

One particular series of satellites presents an additional concern. During the 1970s and 80s the Soviet Union launched a number of naval surveillance satellites as part of their RORSAT (Radar Ocean Reconnaissance SATellite) program. These satellites were equipped with a BES-5 nuclear reactor in order to provide enough energy to operate their radar systems. The satellites were normally boosted into a medium altitude graveyard orbit, but there were several failures that resulted in radioactive material reaching the ground (see Kosmos 954 and Kosmos 1402). Even those satellites successfully disposed of now face a debris issue of their own, with a calculated probability of 8% that one will be punctured and release its coolant over any 50-year period. The coolant self-forms into droplets up to around some centimeters in size and these represent a significant debris source of their own.

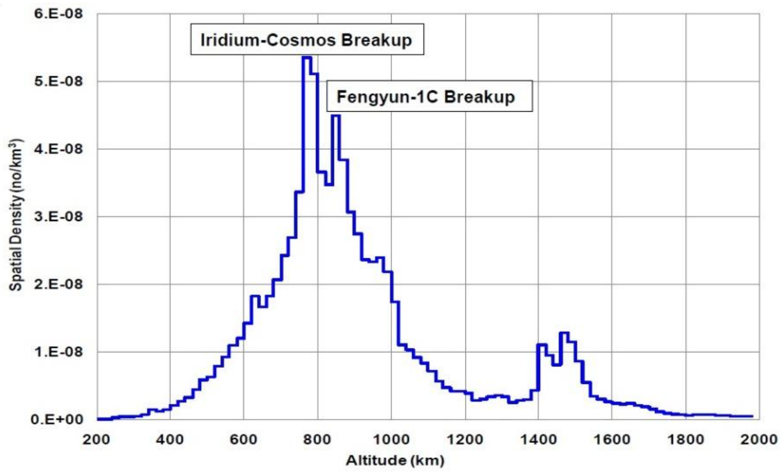
Dealing with space debris.

Manmade space debris has been dropping out of orbit at an average rate of about one object per day for the past 50 years. Substantial variation in the average rate occurs as a result of the 11-year solar activity cycle, averaging closer to three objects per day at solar max due to the heating, and resultant expansion, of the Earth's atmosphere. At solar min, five and one-half years later, the rate averages about one every three days.

External removal debris.

A well-studied solution is to use a remotely controlled vehicle to rendezvous with debris, capture it, and return to a central station. The commercially developed MDA Space

Infrastructure Servicing vehicle is a refuelling depot and service spacecraft for communication satellites in geosynchronous orbit, slated for launch in 2015. The SIS includes the vehicle capability to "push dead satellites into graveyard orbits." The Advanced Common Evolved Stage family of upper-stages is being explicitly designed to have the potential for high leftover propellant margins so that derelict capture/deorbit might be accomplished, as well as with in-space refuelling capability that could provide the high delta-V required to deorbit even heavy objects from geosynchronous orbits.



Spatial density of LEO space debris by altitude according to NASA report to UNOOSA of 2011.

The laser broom uses a powerful ground-based laser to ablate the front surface off of debris and thereby produce a rocket-like thrust that slows the object. With a continued application the debris will eventually decrease their altitude enough to become subject to atmospheric drag. In the late 1990s, US Air Force worked on a ground-based laser broom design under the name "Project Orion". Although a test-bed device was scheduled to launch on a 2003 Space Shuttle, numerous international agreements, forbidding the testing of powerful lasers in orbit, caused the program to be limited to using the laser as a measurement device. In the end, the Space Shuttle Columbia disaster led to the project being postponed and, as Nicholas Johnson, Chief Scientist and Program Manager for NASA's Orbital Debris Program Office, later noted, "There are lots of little gotchas in the Orion final report. There's a reason why it's been sitting on the shelf for more than a decade."

Additionally, the momentum of the photons in the laser beam could be used to impart thrust on the debris directly. Although this thrust would be tiny, it may be enough to move small debris into new orbits that do not intersect those of working satellites. NASA research from 2011 indicates that firing a laser beam at a piece of space junk could impart an impulse of 0.04 in (1.0 mm) per second. Keeping the laser on the debris for a few hours per day could alter its course by 650 ft (200 m) per day. One of the drawbacks to these methods is the potential for material degradation. The impinging energy may break apart the debris, adding to the problem. A similar proposal replaces the laser with a beam of ions.

A number of other proposals use more novel solutions to the problem, from foamy ball of aerogel or spray of water, inflatable balloons, electrodynamic tethers, boom electroadhesion, or dedicated "interceptor satellites". On 7 January 2010, Star Inc. announced that it had won a contract from Navy/SPAWAR for a feasibility study of the application of the ElectroDynamic Debris Eliminator (EDDE). In February 2012, the Swiss Space Center at École Polytechnique Fédérale de Lausanne announced the Clean Space One project, a nanosat demonstration project for matching orbits with a defunct Swiss nanosat, capturing it, and deorbiting together.

As of 2006, the cost of launching any of these solutions is about the same as launching any spacecraft. Johnson stated that none of the existing solutions are currently cost-effective. Since that statement was made, a promising new approach has emerged. Space Sweeper with Sling-Sat (4S) is a grappling satellite mission that sequentially captures and ejects debris. The momentum from these interactions is used as a free impulse to the craft while transferring between targets. Thus far, 4S has proven to be a promising solution.

A consensus of speakers at a meeting held in Brussels on 30 October 2012, organized by the Secure World Foundation, a US think tank, and the French International Relations Institute, report that active removal of the most massive pieces of debris will be required to prevent the risks to spacecraft, crewed or not, becoming unacceptable in the foreseeable future, even without any further additions to the current inventory of dead spacecraft in LEO. However removal cost, together with legal questions surrounding the ownership rights and legal authority to remove even defunct satellites have stymied decisive national or international action to date, and as yet no firm plans exist for action to address the problem. Current space law retains ownership of all satellites with their original operators, even debris or spacecraft which are defunct or threaten currently active missions.

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- List of patents see in end "Patent search".

Brief Summary of the Invention

Author offers a new method and installation (space apparatus) for cleaning the outer Space from Space debris, protection current and future space station, ships, space apparatus from space debris and enemy attack and device which must be installed on new space apparatus for returning them into the planet atmosphere after lifetime or in dangerous situation.

The offered Space Apparatus (Space Cleaner), rocket-projectile, catch net and special Brake-Reflector parachute have next main differences in method and installation from the ordinary method and usual collector of the space debris (see for example: Project "Babushka" of Jozef Resnick and Project Vaughan Ling (fig.8) and patents in "Search section":

Conventional Method:

In usual method the Apparatus has remote control, radio locator, computer, rockets, arms, storage for space debris (Fig.5.). One flys up to Space Debris (SD), brakes its speed to equal the SD, complex maneuvers for getting the suitable position, opens the door of the storage, catches the SD (for example the old satellite), puts into storage, closed the door, turns on the rocket engine and flights to the Earth atmosphere (to dump the SD for burning in atmosphere) or to Space station for repair satellite.

Offered AB Method:

In offered method the Apparatus has remote control, radio locator, computer, small rocket engine. It does not have a big storage for space debris. One can have near the SD a high speed. Apparatus shoots in SD from a guide rails or a special gun by the small special rocket (projectile) having the net and the brake-reflect parachute. The net catches the SD. The special cable uncoils and breaks the SD or pass the SD impulse to SA and accelerate it. The small special rocket-projectile disconnected from SA, opens the brake-reflector parachute and sends the SD into the Earth atmosphere. Space apparatus can save connection to satellite and delivery it to the Space Station or Space ship.

No operations: braking at near SD, complex maneuvers of SA at near SD. Arms for catching SD, putting SD into storage, delivery SD to the Earth atmosphere (spending fuel). Further acceleration (spending fuel) for fly back to space.

Author also offers new method and installation for cleaning the outer space from space debris and individual protection the important space ship and stations from big space debris (SD). Advantages of the offered method and apparatus are following: 1. Less size and weight in 2 -3 times than conventional SD Collector. 2. More efficiency in 2 -10 times. 3. Save fuel in some times. 4. No limits in size for SD. 5. Can easy protect selected space ship and station (for example, International Space Station) from SD.

Brief Description of the Several Views of the Drawings in Description and Notations in Each Drawing

Fig.1. The Problem of returning the Space Debris to the Earth. (a)- Trajectories os SD having a high apology (> 500 km). (b)- Spiral trajectory of SD having the initial cirle trajectory in the Earth atmosphere (< 100 km). Notations: 1 - Earth, 2 - Earth atmosphere, 3 - boundary of the Earth atmosphere, 4 - SD or SA, 5 - trajectory of SD or SA.

Fig.2. Braking/acceleration of the Space Debris by the parachure-reflector. (a) - braking, $F_2 > F_1$; (b) - acceleration, $F_2 > F_1$ (again direction of apparatus moving). *Notations*: 1 - Earth, 2 - Earth atmosphere, 3 - SD or SA, 4 - paraphute-reflector, 5 - trajectory of the SD/SA, 6 is solar radiation. F_1 and F_2 are the light force (pressure).

Fig. 3. AB Method. Process of catching and braking SD: (*a*) - shot of SA 1 by special projectile 3; (*b*) - open the special net 4 for catching the debris 2; (*c*) - space debris after its catching; (d) - braking SD by projectile which is used the cable 5; (e) - the (air/solar light) braking by parachute/reflector 6.

Notations: 1 - Space apparatus (SA); 2 - Space debris (SD), 3 - reactive gun, 4 - catch net, 5 - brake cable, 6 - control parachute, reflector, mirror, brake.

Fig.4. Some possible forms of the offered Drag-Reflect Space Brake (Parachute, Sail). *Notations*: (*a*) - forward view of drag-Reflector, (*b,c*)- side view of drag-reflector and parachute, (*d*) - spherical drag-reflector, (*e*) - net (grid) for catching the space debris; 1 - inflatable ring (toroid), 2 - thin film (or solar sail), 3 - parachute, 4 - inflatable thin film ball, 5 - connection cables; 6 - direction of moving, 7 - light thin net (grid), 8 - partition into toroid.

Fig.5. Possible design of the offer AB Space Apparatus (AB Space Cleaner). Notations: (*a*) - side view, (*b*) - forward view; 1 - offer AB Space Cleaner; 2 - head section contains: locator, TV and radio translator, radio receiver, computer, control and so on; 3 - storage for the small pieces of the space debris; 3 - rocket engine section; 4 - doors and artificial arms for catching the space debris; 5 - maneuver small rocket engines; 6 - projectiles for catching the big objects or pieces of the space debris (for example satellites, last rocket stagy); 7 - storage for the small pieces of the space debris; 8 - fuel for main rocket engine; 9 - main rocket engine.

Fig.6. Projectile for catching and braking or delivery to space station the satellite for repair. Notations: (*a*) - side view; (*b*) - the forward view; 1 - projectile body; 2 - head section contains: locator, TV and radio translator, radio receiver, computer, control and so on; 3 - brake parachute or solar sail; 4 - maneuver small rocket engines; 5 - net section; 6 - solid fuel section of rocket engine; 7 - rocket engine.

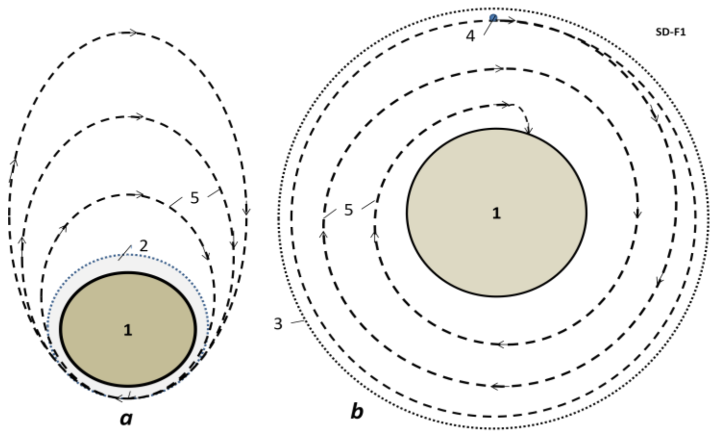
Fig.7. Cartridge of parachute for quick landing the space apparatus. Notations: 1 - body, 2 - brake parachute, 3 - air balloon for inflatable ring or ball, 4 - knockout charge, 5 - direction of parachute moving, 6 - fuse.

Detailed Description of the Invention

Air (Atmosphere) Braking. Deleting of Space Debris (SD) from Space is very expensive. One is more expensive than producing and launch the new satellites. You must design the special Debris Apparatus (DA), launch him. One must have the enough fuel for flight, braking and connection to the given piece of space debris, braking (DA and SD), to delivery them (together DA and SD) to the Earth atmosphere and, accelerate DA, to fly in next debris and repeating all maneuvers (flight, braking, connection, impulse of braking, acceleration and so on) to the next piece of debris.

Author offers the new economical method of deleting the SD (Brake-Reflector). Braking the SD by the special light parachute-reflector (mirror , space sail) which is used the space gas of a top atmosphere and a solar pressure. This method also may be used by the interplanetary space apparatus (SA) for acceleration, braking and landing of SA on planets.

The problem of cleaning the Space is shown in Fig.1.



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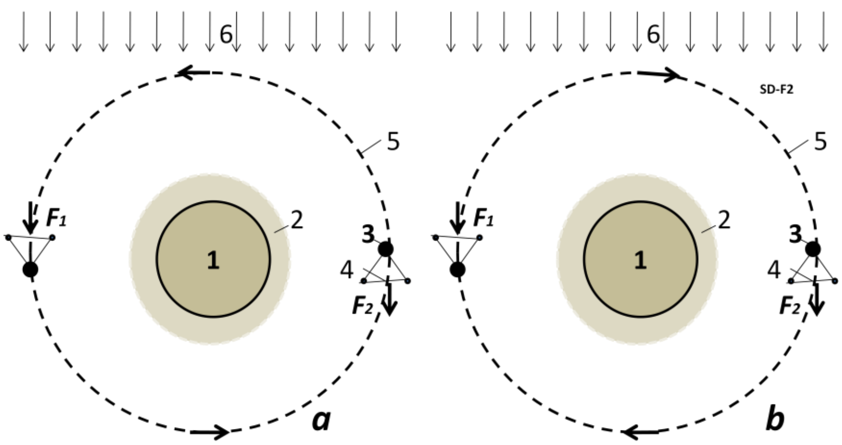
The air brake works the following way. Apparatus/debris has the ellipse trajectory. The Earth is located in focus of ellipse. The minimal altitude is named – perigee, the maximal altitude is named –apogee (Fig.1a). When apparatus are into the Earth atmosphere, the air drag brakes one. As result the apogee decreases while the trajectory became a closed to circle and fully locates into the Earth atmosphere. Here from air drag the trajectory has form of spiral. The small debris/apparatus burns in atmosphere. The big SD/SA or having the special control parachute can lend the SA to Earth surface.

This method may be used if the altitude of perigee is less 350 km. If the altitude is more 350 – 450 km the SD/SA lifetime is some (tens) years (see Computation section). That may be not acceptable for humanity.

Solar braking/acceleration. In this method the SD/SA connects with specil thin film solar sail or parachute has surfaces having a different color. For example, blask-white or black-mirror. As the result the solar pressure (solar radiation) on sail (parashute) in left and right sides of circle orbite will be different (Fig.2) ($F_2 > F_1$). If the braking is more than acceleration, the SD/SA will decrease the perigee (Fig. 2a). If the braking is less than acceleration. The SD/SA will increse the apogee (Fig. 2b).



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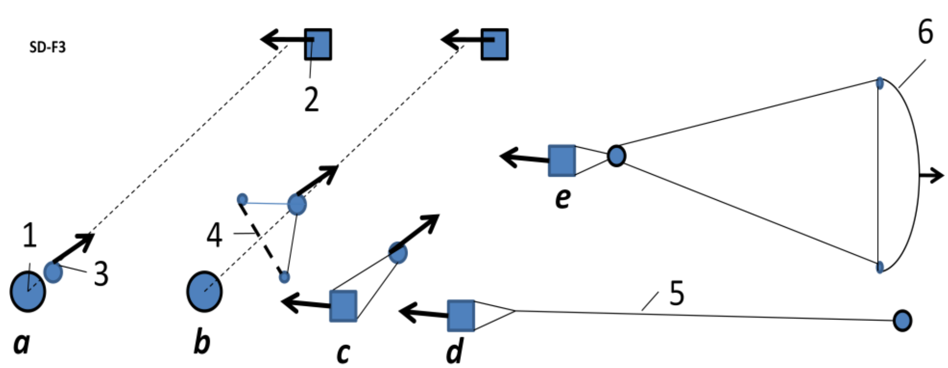
Work of the offered Apparatus.

The work of the offered Brake-Reflector is shown in fig.3. The Debris Apparatus 1 (DA) fly up to space debris (SD) 2 and shutting by a small rocket projectile 3 (fig.3a). (That may be connected by thin cable to Debris Apparatus 1). The projetale opens a net 4 (fig.3b). The net 4 catches the space debris 2 (fig. 3c) and releases, unwind (reel off) a brake cable 5 (fig.3d). As the result the SD pass its inpuls to the projectale 3 or SA 1. The SD is braked, the SA (if one connected to SD) gets the acceleration. After this the prijectale disconnected from SA 1 (if it was connected to SA 1), open the Brake-Reflector 6 and brakes the space debris 3 by the Brake-Reflector 6 in the top atmosphere or/and the solar radiation (fig.3e). The Space Apparatus flights to next SD or delivery the important satellite to Space Station for repair.



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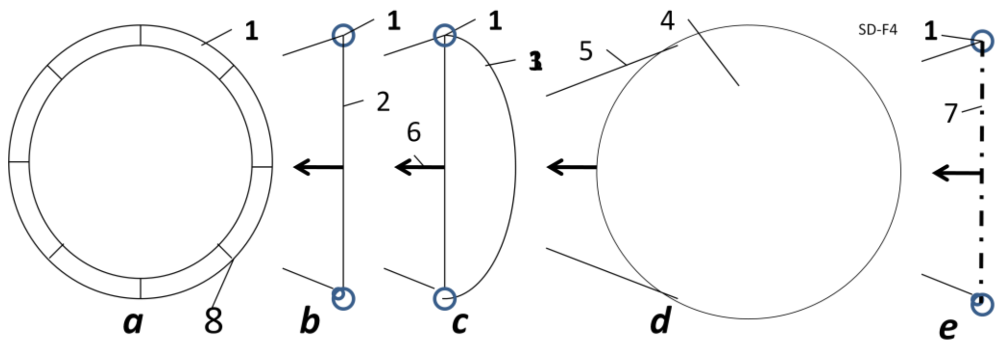
Notations: 1 – Space apparatus (SA); 2 – Space debris (SD), 3 – reactive gun, 4 – catch net, 5 – brake cable, 6 – control parachute, reflector, mirror, brake.



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Design of offered apparatus

One possible design of the AB Space Apparatus (Space Cleaner) is shown in Fig.5.

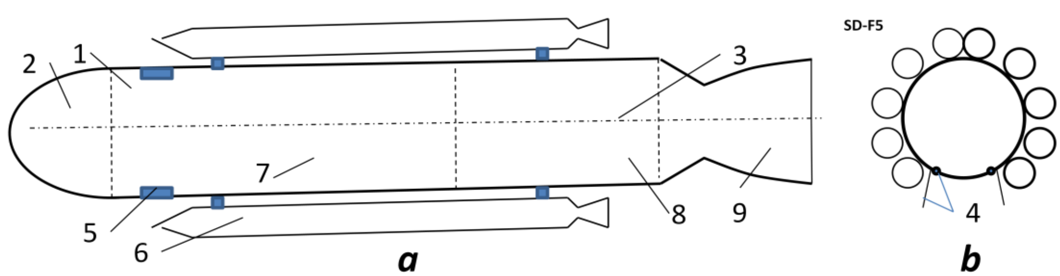

Fig.5. Possible design of the offer AB Space Apparatus (AB Space Cleaner).
Notations: (***a***) – side view, (***b***) – forward view; 1 – offer AB Space Cleaner; 2 – head section contains: locator, TV and radio translator, radio receiver, computer, control and so on; 3 – storage for the small pieces of the space debris; 3 – rocket engine section; 4 – doors and artificial arms for catching the space debris; 5 – maneuver small rocket engines; 6 – projectiles for catching the big objects or pieces of the space debris (for example satellites, last rocket stagy); 7 – storage for the small pieces of the space debris; 8 – fuel for main rocket engine; 9 – main rocket engine.

The projectile for catching the large space objects is shown in fig.6.

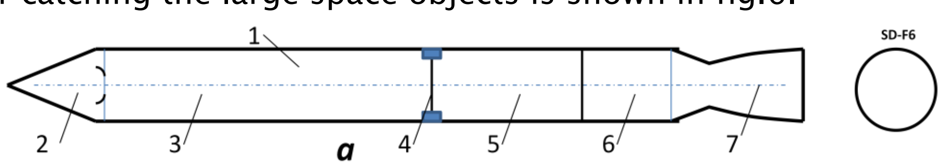

Fig.6. Projectile for catching and braking or delivery to space station the satellite for repair. Notations: (*a*) – side view; (*b*) – the forward view; 1 – projectile body; 2 – head section contains: locator, TV and radio translator, radio receiver, computer, control and so on; 3 – brake parachute or solar sail; 4 – maneuver small rocket engines; 5 – net section; 6 – solid fuel section of rocket engine; 7 – rocket engine.

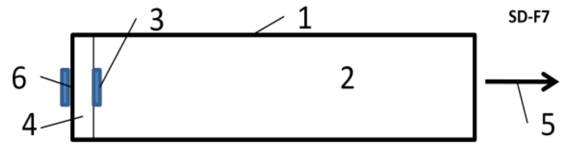

Fig.7. Cartridge of parachute for quick landing the space apparatus. Notations: 1 – body, 2 – brake parachute, 3 – air balloon for inflatable ring or ball, 4 – knockout charge, 5 – direction of parachute moving, 6 – fuse.

Differences and Innovations in AB Method and Apparatus.

The offered Brake-Reflector has next differences in method and installation from the ordinary method and usual collector of the space debris (see Project "Babushka" of Jozef Resnick and Project Vaughan Ling (fig.8):

Conventional Method:

In usual method the Apparatus has remote control, radio locator, computer, rockets, arms, storage for space debris (Fig.5.). One flys up to SD, brakes its speed to equal the SD, complex maneuvers for getting the suitable position, opens the door of the storage, catches the SD (for example the old satellite), puts into storage, closed the door, turns on the rocket engine and flights to the Earth atmosphere (to dump the SD for burning in atmosphere) or to Space station for repair satellite.

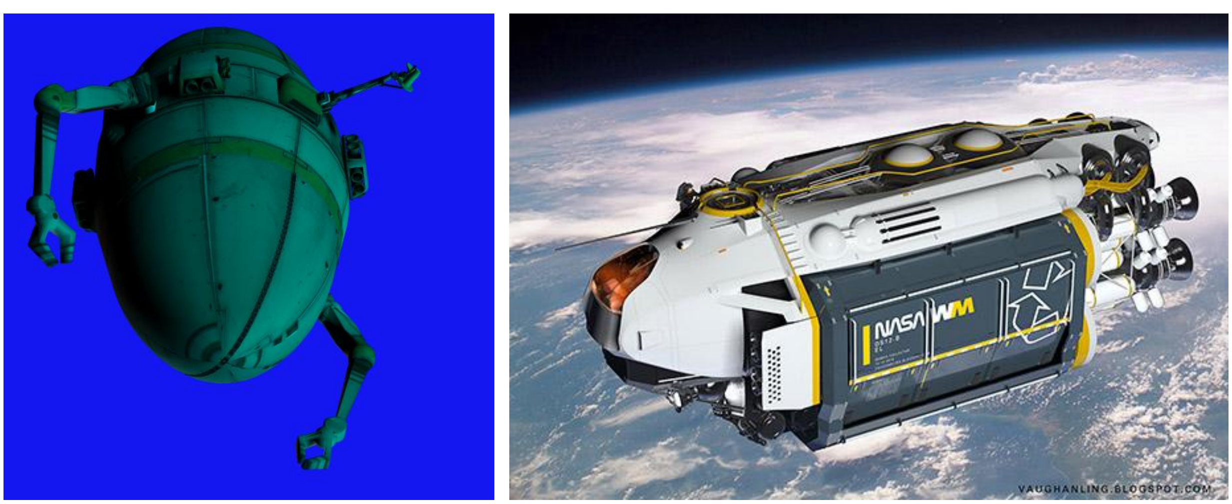

Fig.8. Project "Babushka" (left) and Vaughan Ling (right) for collection the space debris.

Offered AB Method:

In offered method the Apparatus has remote control, radio locator, computer, small rocket engine. It does not have a big storage for space debris. One can have near the SD a high speed. Apparatus shoots in SD from a guide rails or a special gun by the small special rocket (projectile) having the net and the brake-reflect parachute. The net catches the SD. The special cable uncoils and breaks the SD or pass the SD impulse to SA and accelerate it. The small special rocket disconnected from SA., opens the brake-reflector parachute and sends the SD into the Earth atmosphere. Space apparatus can save connection to satellite and delivery it to the Space Station or Space ship.

No operations: braking at near SD, complex maneuvers of SA at near SD. Arms for catching SD, putting SD into storage, delivery SD to the Earth atmosphere (spending fuel). Further acceleration (spending fuel) for fly back to space.

Advantages of the offered AB apparatus (AB Collector of space debris).

1. Less size and weight in 2 -3 times than conventional SD Collector (Not need in big storage for SD).
2. More efficiency in 2 -3 time (it can collect more SD).
3. Need less of fuel in some times (No maneuvers at SD, it can get the impulse from SD, SA can be far from SD and has a high speed).
4. No limits in size for SD. (All old and new space satellites have the solar panels and they can NOT be deleted by other space apparatus, fig. 9).
5. May easy protect selected space ship and station (for example, International Space Station) from SD.
6. The brake-reflector parachute makes SD easy for view and detection by locator).

Conclusion

Author offers a new method and installation (space apparatus, cleaner) for cleaning the outer Space from Space debris, protection current and future space station, ships, space satellites and interplanetary apparatus from space debris, meteorites and enemy attack and device which must be installed on new space apparatus for returning them into the planet atmosphere after lifetime or dangerous situation.

Space cleaner has the special small rockets-projectiles. Rockets have a net and special brake-reflector parachute. Space cleaner shoots the special small rocket to space debris (attack projectile), catch them by net, change the debris impulse, connects to them brake-reflect parachute and return debris to planet using the top atmosphere and solar pressure.

Offered method and installation have the great advantages in comparison with usual method and space cleaner collecting the space debris into container. Offered space apparatus saves its weigh, fuel, has a big efficiency and can delete large space debris.

Summary

Method

(1) A method of Space Cleaning from space comprising of steps:

Launching a special Space Apparatus (cleaner) into outer space;

Discovering the space debris by a special locator located in said Space Apparatus;

Turning said Space Apparatus in a need position for shooting;

Shooting by a special small rocket projectile located on said Space Apparatus to space debris;

Catching the space debris by a special catching net located and connected to the said small rocket projectile;

Changing an impulse (braking/acceleration) of space debris by a special cable located in said small rocket projectile and connected to it and said catching net;

Releasing a special brake-reflect parachute connected to said projectile;

Braking said space debris using a top atmosphere planet and a solar radiation.

(2) The Method of Space Cleaning as recited above in point (1) comprising at least one of the following additional steps:

Navigation said Space Apparatus by space navigator located in said Space Apparatus;

Locating said Space Apparatus by a special radio beacon located in said Space Apparatus;

Guidance of launching projectile by TV camera installed in said Space Apparatus;

Guidance of flight projectile and catching said space debris by TV camera installed in said projectile;

Controlling and guidance the flight and operations of said Space Apparatus by computer and the special programs located in said Space Apparatus;

Controlling and guidance the flight and operations of said Projectile by computer and the special programs located in said Projectile;

Catching the space debris by a special artificial arm located and connected to the said Space apparatus;

Installation:

(3) An Installation utilized the Method of the Space Cleaning comprising devices:

a) Main rocket engine for long distance flight and change orbit;

b) Small rocket engine for maneuvers;

c) Locator for searching said Space Debris;

d) Issue of energy;

e) Said rocket projectiles;

(4) The Installation recited above in point (3) comprising at least one of the following devices and features:

1) Separated Section of main rocket engine contains a fuel capsule for quick repair and change the fuel capsule;

2) Separated Section of maneuver rocket engine contains a fuel capsule for quick repair and change the fuel capsule;

3) Separated Section of said projectiles for quick change the projectiles;

4) TV camera and translator for search and inspection said Space Debris;

5) Radio and TV translator for translation video and commands to and from operator;

6) Remote control and guidance;

7) Storage for small pieces of space debris;

8) Artificial arm for operation with said Space debris.

(5) The Projectile recited above in point (4) comprising at least one of the following devices and features:

1) Said Projectile has a rocket engine for shooting;
2) Said Projectile has Locator and TV camera for correction of its trajectory;
3) Said Projectile has a catch net for capture the space debris;
4) Said Projectile has a special brake-reflector parachute for braking the space debris;
5) Said Projectile has a special cable and brake mechanism for decreasing an impact force in the moment of catching said space debris by said catch net;
6) Said net and brake-reflect parachute have special mechanism for realizing and opening (for example inflatable toroid and gas balloon).

(6) An Installation utilized said Method (1) of the Space Cleaning (deleting the space debris from future space apparatus such as: satellites, last stages rockets and so on) comprising devices:

1) Cartridge for space brake-reflect parachute, located in the future space apparatus;
2) Said brake-reflect parachute into said cartridge;
3) Special mechanism for realizing and opening said brake-reflect parachute;
4) Knockout charge into said cartridge;
5) inflatable toroid connected to said brake-reflect parachute;

6) gas balloon connected to said toroid.

Formula of invention (Claims)

Method

[Claim 1] A method of Space Cleaning from space comprising of steps:

1) Launching a special Space Apparatus (cleaner) into outer space;
2) Discovering a space debris by a special locator located in said Space Apparatus;
3) Flying to said discovered space debris;
4) Turning said Space Apparatus in a need position for shooting;
5) Shooting by a special small rocket-projectile located on said Space Apparatus to space debris;
6) Catching the space debris by a special catching net located and connected to the said small rocket-projectile;
7) Changing an impulse (braking/acceleration) of said space debris by a special cable located in said small rocket-projectile and connected to it and said catching net;
8) Releasing a special brake-reflect parachute connected to said projectile;
9) Braking said space debris using a top atmosphere planet and a solar radiation.

[Claim 2] The Method of Space Cleaning as recited above in [Claim 1] comprising at least one of the following additional steps:

1) Navigating said Space Apparatus by a space navigator located in said Space Apparatus;
2) Locating said Space Apparatus by a special radio beacon located in said Space Apparatus;
3) Guidance of said launching projectile by a TV camera installed in said Space Apparatus;
4) Guidance of flight said projectile and catching said space debris by said TV camera installed in said projectile;
5) Controlling and guidance the flight and operations of said Space Apparatus by a computer and special programs located in said Space Apparatus;
6) Controlling and guidance the flight and operations of said Projectile by a computer and the special programs located in said Projectile;
7) Catching said space debris by a special artificial arm located and connected to the said Space apparatus;

Installation:

[Claim 3] An Installation utilized the Method of the Space Cleaning comprising devices:

1) Main rocket engine for long distance flight and change orbit;
2) Small rocket engine for maneuvers;
3) Locator for searching said Space Debris;
4) Issue of energy;
5) Said rocket projectiles;

[Claim 4] The Installation recited above in **[Claim 3]** comprising at least one of the following devices and features:

1) Separated Section of main rocket engine contains a fuel capsule for quick repair and change the fuel capsule;
2) Separated Section of maneuver rocket engine contains a fuel capsule for quick repair and change the fuel capsule;
3) Separated Section of said projectiles for quick change the projectiles;
4) TV camera and translator for search and inspection said Space Debris;
5) Radio and TV translator for translation video and commands to and from operator;
6) Remote control and guidance;
7) Storage for small pieces of space debris;
8) Artificial arm for operation with said Space debris.

[Claim 5] The Projectile recited above in **[Claim 4]** comprising at least one of the following devices and features:

1) Said Projectile has a rocket engine for shooting;
2) Said Projectile has a Locator and TV camera for correction of its trajectory;
3) Said Projectile has a catch net for capture a space debris;
4) Said Projectile has a special brake-reflector parachute for braking said space debris;
5) Said Projectile has a special cable and a brake mechanism for decreasing an impact force in the moment of catching said space debris by said catch net;
6) Said net and brake-reflect parachute have a special mechanism for realizing and opening (for example an inflatable toroid and a gas balloon).

[Claim 6] An Installation utilized said Method in **[Claim 1]** of said Space Cleaning (deleting said space debris from the future space apparatus such as: satellites, last stages of rockets and so on) comprising devices:

1) Cartridge for a space brake-reflect parachute, located in the future space apparatus;
2) Said brake-reflect parachute into said cartridge;

3) Special mechanism for realizing and opening said brake-reflect parachute;
4) Knockout charge into said cartridge;
5) Inflatable toroid connected to said brake-reflect parachute;
6) gas balloon connected to said toroid.

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ABSTRACT

Author offers a new method and installation (space apparatus, cleaner) for cleaning the outer Space from Space debris, protection current and future space station, ships, space satellites and interplanetary apparatus from space debris, meteorites and enemy attack and device which must be installed on new space apparatus for returning them into the planet atmosphere after lifetime or dangerous situation.

Space cleaner has the special small rockets-projectiles. Rockets have a net and special brake-reflector parachute. Space cleaner shoots the special small rocket to space debris (attack projectile), catch them by net, change the debris impulse, connects to them brake-reflect parachute and return debris to planet using the top atmosphere and solar pressure.

Patent Investigation

8,657,235 Space debris removal using upper atmosphere and vortex generator .

8,628,044 Stabilization of unstable space debris

8,403,269 Orbit debris removal and asset protection assembly

8,579,235 Technique for de-orbiting small debris from the near-earth space environment
8,567,725 Orbital debris mitigation system and method
8,496,208 Orbit debris removal and asset protection assembly
8,485,475 Debris removal management system and method of operation thereof
8,469,314 Technique for de-orbiting small debris from the near-earth space environment
8,386,099 Method and apparatus for initial orbit determination using high-precision orbit propagation and maneu
8,226,046 Stabilization of unstable space debris

8,052,092 Method and apparatus for satellite orbital change using space debris

7,309,049 Orbital debris shield

7,297,968 Debris collector for EUV light generator

7,178,763 Passive deployment mechanism for space tethers

7,105,791 Orbital debris detection and tracking system utilizing sun or moon occlusion

International patent search (Foreign Patent Documents)

Space Debris Removal

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Space debris removal

WO 2012128851 A1

Patent application title: SPACE DEBRIS REMOVAL USING UPPER ATMOSPHERE Publication date: 2013-11-21

Patent application number: 20130306799

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