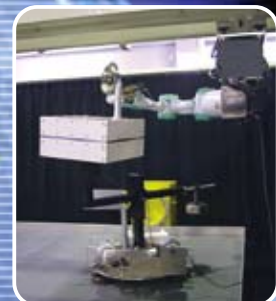




Technologies for Space Debris Mitigation



SPACE DEBRIS MITIGATION



Test-bed for space debris capture

Mitigation

Space debris removal system

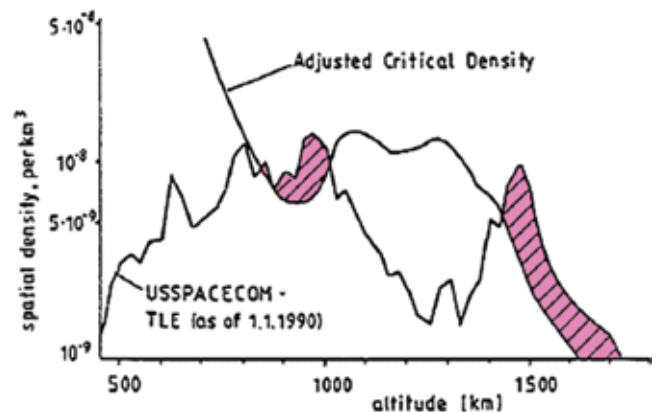
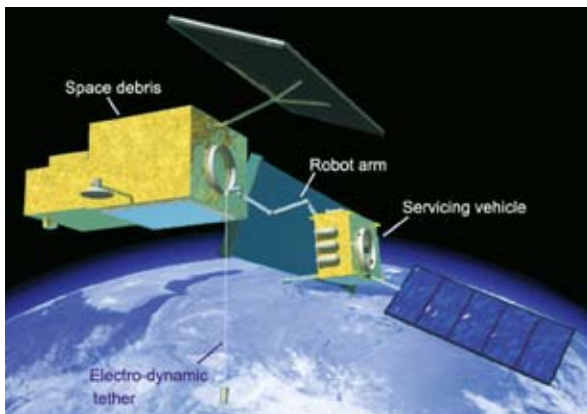
Space debris removal system:

Clearly the most fundamental way to solve the space debris problem is to reduce the quantity of space debris. The Kessler Syndrome is especially likely to occur at altitudes at which space debris is concentrating. It is thought that removing about 100 items of space debris from these altitudes could prevent the Kessler Syndrome. JAXA is studying a "space debris removal system" for this purpose. A space debris removal satellite will require high autonomy and functionality for capturing space debris objects, and an efficient propulsion system to remove them from orbit.

The Electro-dynamic tether is the propulsion technology which is the key to the space debris removal system.

If a tether wire several kilometers long is extended in orbit and an electrical current passed through it, a "Lorentz force" will be generated by interaction of the current and the earth's magnetic field which will act to slow down the object to which the tether is attached and so reduce its altitude.

By attaching an EDT module to space debris items, it will be possible to remove them from orbit with hardly any fuel or electric power.



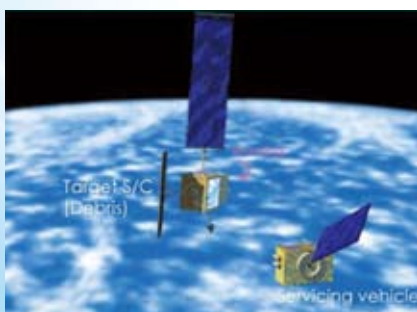
Kessler, Collisional cascading: The limits of population growth in low Earth orbit, *Advances in Space Research* 11(12):63-66, 1991

Space debris removal process:

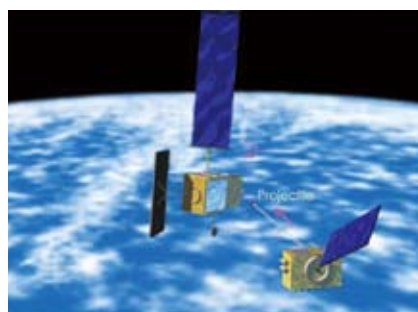
A space debris removal satellite is used to remove large items of space debris. The satellite first maneuvers towards a debris object and measures its motion. If the object is rotating or tumbling at an appreciable rate, it will first slow the object's motion. It will then maneuver around the debris object, capture it using

a robot arm and attach an "electro-dynamic tether (EDT)" before releasing it and moving off to other space debris.

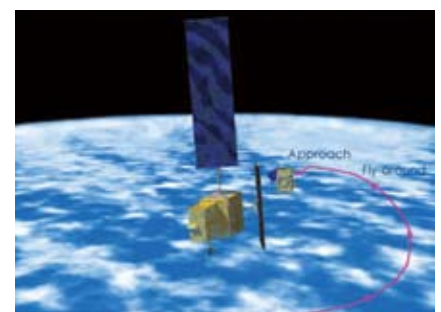
The EDT then lowers the altitude of the debris object until it re-enters the atmosphere and burns up.



STEP1 : Motion measurement



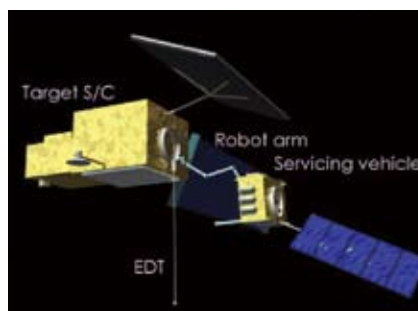
STEP2 : Momentum reduction



STEP3 : Fly-around & approach to target



STEP4 : Capture of target



STEP5 : Deployment of tether



STEP6 : Release of target

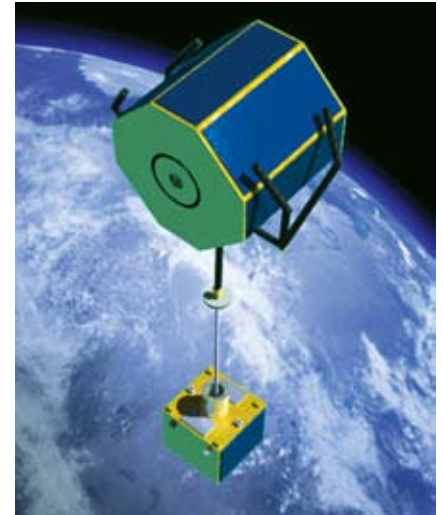
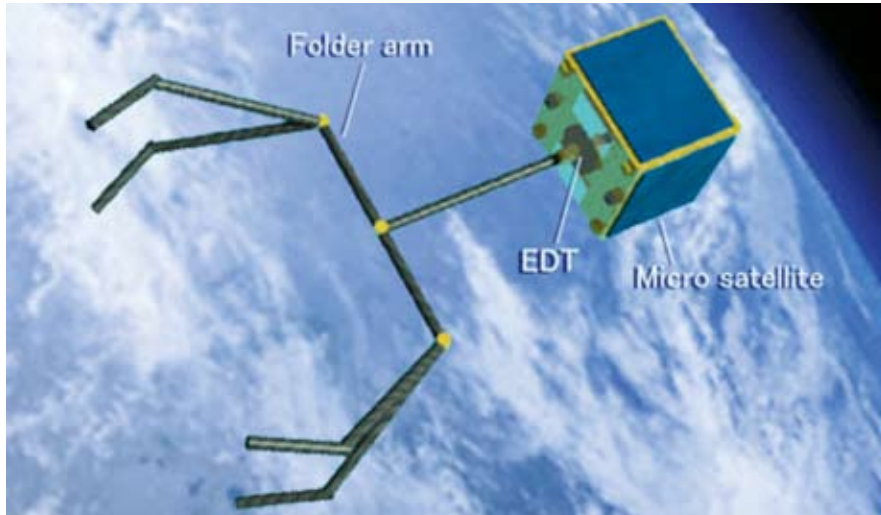


Micro remover:

Besides the large debris object removal system, a small expendable "micro remover" with an electro-dynamic tether module is being considered.

If such a "micro remover" is small enough, it can be launched "piggyback" with another satellite such as a new earth observation satellite, and debris removal can be performed efficiently in orbits with much space debris.

By this method, each new satellite launch will allow the removal of one piece of space debris.

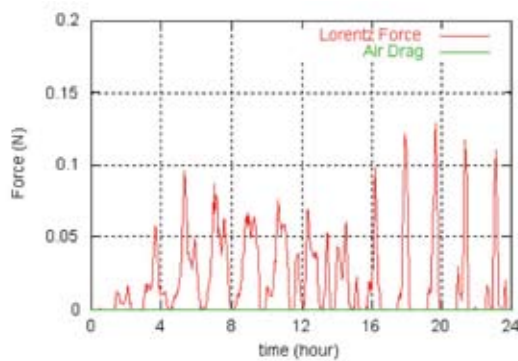


Electro-dynamic tether;

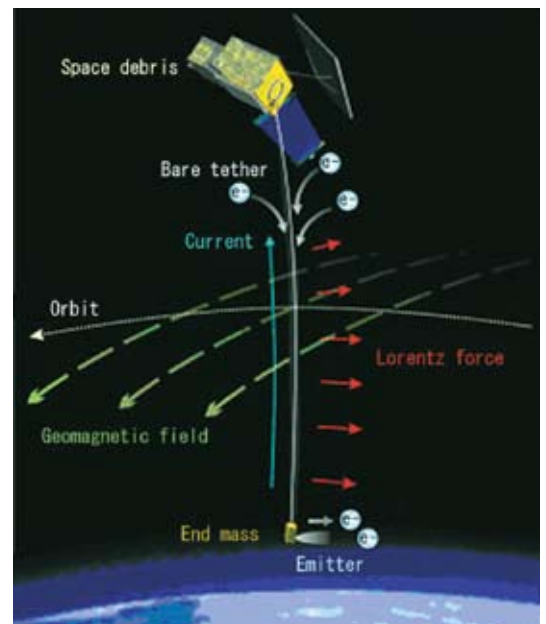
Electro-dynamic tether is the propulsion technology used as the key of a space debris removal system.

If a several km length tether wire is extended on an orbit and current is passed there, the "Lorentz force" can occur by the interaction of geomagnetic field and current, and the space debris can be decelerated.

By attaching this EDT module to the space debris, it becomes possible to drop the orbit of the space debris, without hardly needing fuel and electric power.



Simulation result of Lorentz force caused by EDT in 800km sun-synchronous orbit



Prototype of a mesh type tether



Prototype of an electron emitter



Prototype of a reel mechanism



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