Space debris has been a hot topic for the last few decades, ever since the space industry started growing exponentially. Everyone agrees that space debris is a growing problem and the saturation point has almost been reached. With a big risk of a chain reaction, called the Kessler syndrome, billions of euro’s worth of space equipment is at risk. Clearly something has to be done about this.

Everyday, NASA tracks 21,000 pieces of debris larger than 10cm and estimates that there are around 500,000 objects between 1cm and 10cm. These objects are untraceable from earth and carry energy equivalent to 0.3kg to 300kg of TNT. The ISS, the most heavily shielded spacecraft ever built, can only withstand particles up to 1cm in diameter to its most critical components. This poses a growing risk to the crews in space and the multibillion-euro equipment they are operating.

One of the main problems with this space debris is that the problem will not disappear in the short term all by itself. Even by suspending all future planned space missions the problem will remain for the coming hundreds of years. Clearly a solution is needed.

LEGAL ISSUES
One of the main challenges facing the battle against space debris is Article VIII of the Outer Space Treaty. This treaty states that any space object, including space debris and non-functional satellites, are still owned by the country that launched them. Unlike maritime law there are no salvage rights, so if a satellite is no longer functional this does not mean a nation has abandoned it. So unless a nation gives its consent to removing a satellite or space object, it cannot be disposed of or even interfered with. Another major complication is the fact that international space law defines parts of spacecraft or other objects as individual space objects. Therefore, if one would even want to remove a speck of dust, that speck would first have to be identified before it can be removed. Liability even further complicates the entire process. Article VI of the Outer Space Treaty states that any nation under whose jurisdiction the removal of the debris is carried out retain full responsibility for the operation and any accident during the operation. This of course means that nations are very reluctant to carry out any mission that will not render any profit, but which could possibly end in a very expensive ordeal.
CLEAN-ME PROJECT
The Swiss Space Centre is developing a space program that is planning to launch a series of Nano satellites as early as 2018. The first satellite in this series, CleanSatOne, will be launched by the SOAR space plane, which is operated by S3 (Swiss Space Systems). It is predicted that the launch costs will be cut to a quarter of the current costs and drastically reduce the footprint of the mission by returning the launcher directly to earth.

The first object to be cleaned by CleanSatOne will be the Nano satellite SwissCube, this in order to avoid potential legal issues surrounding the de-orbiting of a foreign satellite. A potential hazard for the system is the potential military application as an Anti-Satellite weapon. After launch the clean-up satellite will match its trajectory to the target’s orbital plane. Traveling at 28,000 km/h at an altitude of around 700 km grabbing an object is tricky and dangerous procedure, with the potential risk of breaking up the target or sending it in a collision orbit with another object. In the case of SwissCube, the system will try to stabilize it and de-orbit itself causing both satellites to burn in the atmosphere.

Even though this is a great start and it shows the willingness of a country to take responsibility for its space debris, the entire operation is extremely difficult, pricey and will only be able to tackle big objects.

CUBESAIL
Surrey Satellite Technologies (SST) in the UK is also involved in the space cleaning business. Currently they are researching solar sails, which employ a huge sail pushed by solar pressure through space. By not having to carry any propellants and only a few moving parts, these solar sails can offer a very cheap alternative to conventional propellant powered spacecraft. SST plans however to deploy solar sails to slow down space debris and thus deorbiting it. Thus, it is possibly a much cheaper alternative to the Clean-mE project.

The mission will be as follows. The CubeSail will be launched into orbit and using a harpoon or net the space debris is captured. Once the debris is caught the solar sail will be deployed and this will create massive drag, causing both the satellite and debris to burn up in the atmosphere.

CubeSail could also be fitted to future satellites. This would mean that in time every single satellite could deorbit itself cheaply and effectively after it has reached its end of life. Deorbiting satellites has always been a costly affair, since every single gram of propellant can be used to extend the lifetime of the multi million-euro missions.

LASER ORBITAL DEBRIS REMOVAL (LODR)
LODR uses the impulse generated by particles that are being burnt on the objects surface. For this system to be effective about 75kJ/m² on the object in 5ns is required, since this creates a plasma jet. One pulse can slow small debris 10cm/s and only nanometers of the surface are vaporized, so the object is not really affected by the process. With a pulse rate of 10Hz and an average power of 75kW, the laser can slow targets up to 10cm in diameter in a single overhead pass. Only about 100m/s is required to slow down an object sufficiently for it to re-enter and burn up in the atmosphere. Low operating costs and high agility are the main advantages of this system. De-orbiting large objects would only cost under a million Euros and even a small LODR system will be capable of tackling objects as much 1000kg. This system would have to be operated by an international agency to avoid legal issues of the Outer Space Treaty.

CONCLUSION
There are many options to remove debris from space and many more concepts are being worked out every day. It is just a matter of time until something goes really wrong in space before nations will finally actively start removing debris. 

REFERENCES
http://stratrisks.com/geostrat/9353
http://orbitaldebris.jsc.nasa.gov/faqs.html#8
http://www.space.com/23049-space-junk-satellite-swiss-space-plane.html
http://space.epfl.ch/page-61745-en.html
http://www.aerospace.org/cords SPACE-debris-basics/what-are-the-risks/
http://www.dailymail.co.uk/sciencetech/article-2317754/Space-sails-carrying-suicidal-satellites-destroy-dangerous-space-junk-good.html
http://www.thespaceview.com/article/21301
http://spie.org/x84761.xml

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