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Asteroid Impact Protection Long Term Solution

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Abstract

The asteroid impact problem is long term since we know most large asteroids that are danger to the Earth. Therefore, a long-term solution is appropriate to consider. This paper presents an asteroid orbit control strategy that results in complete protection that is sustainable in time and near zero cost. The confluence of advancing AI with advancing robotics together with technologies developed for Lunar stations and Mars settlements can produce the solution presented in this paper.

This solution uses advanced robotics with evolved AI and advanced technologies in using 3D machines and ISRU to make thrusters and fuel with required structure assemblies to provide a thrust operation and strategy to make small continuous adjustments to the asteroid orbit. This would result in a slow migration of the asteroid orbit out of the Earth – Moon – Mars vicinity and into the Asteroid Belt.

The AI Robots would be able to duplicate themselves, make transfer rockets and navigate to other asteroids.

Introduction:

The desire for this solution to prevent asteroid impacts on the Earth and in the near future the Moon and Mars with as little cost as possible is currently on a development path due to several major programs being conducted by space agencies and high-level directives. Of course, the major program at this time is the return to the Moon to set up at least a semi-permanent base for Lunar exploration and science by the Artemis Program of NASA. This has a political push since there is a high desire to land on the Moon before China to capture space technology leadership and preserve national pride. There are many technologies that are being or will be

developed for this program to succeed. These technologies include the production of food, water, energy, fuel, breathable air, mining for required materials, and manufacturing of machines including parts and repair capabilities as well as living domains. Robotics with space AI capabilities (**ASI**) and use of in-situ resource utilization (**ISRU**) technologies are keys to a successful program.

ISRU has always been a key to successful human expansion on the Earth. Many times, a group of humans set off to expand to parts un-settled like Antarctica or the Western United States without planning for their needs beyond a short time or thinking others will provide logistical support, and when that did not happen, they perished. Usually, only when they were able to use the resources on the land they expanded on, did they survive and grow.

In 2005, Congress mandated NASA to detect, track, and catalogue at least 90% of all Near-Earth Objects (NEOs) 140 meters or larger in diameter by 2020 and include analysis of potential deflection alternatives. Known as the [George E. Brown, Jr. Near-Earth Object Survey Act](#) (Section 321 of the 2005 NASA Authorization Act), this directive aimed to identify potentially hazardous asteroids capable of causing massive devastation. (Ref. 1.) At this time (2026) NASA has detected a little less than half of the 25,000 NEOs in this category and the **NEO Surveyor mission** expected to launch in late 2027 should close the gap. Congress also required NASA to find ways to divert a threatening asteroid. The DART (Double Asteroid Research Target) impact mission hit the asteroid moon Dimorphos on September 26, 2022, and significantly changed its orbit around the asteroid Didymos. This was the first time humans made a measured change to our Solar System.

Other means of planetary defense include what is called a gravity tractor where a heavy spacecraft with a low thrust engine would pull on the asteroid slowly to change its flight trajectory (Ref. 3 & 4). Another means is to use several heavy impactors on the asteroid to nudge it off course. Another means is to use laser ablation that generates gas and dust which creates a thrust to move the asteroid off course. Another means is to use an atomic blast in a crater on the asteroid to push it off course. These defenses are addressed in References 3 & 4).

These means of asteroid deflection are good as a last resort to avoid an impact if a primary strategy does not work or if the asteroid (or comet) is detected too late for a primary strategy to do the job. But the main problem is that the asteroid may miss the Earth (or Moon or Mars) on its current path but on a succeeding orbit may come closer and still be a problem. Ideally, we would want to move the asteroid orbit away from the Earth-Moon-Mars areas and put it into the Asteroid Belt. This requires a solution here – an Asteroid Control Thruster Strategy (**ACTS**) as a primary strategy.

[An Asteroid Control Thruster Strategy:](#)

A Thrust Control Strategy is to simply attach a thruster of appropriate size to the asteroid and have it push the asteroid in a guided direction to slowly shift its trajectory in the desired way. The major tool to do this is advanced robotics with space intelligence (ASI). This is a robot or a set of robots that would tether to an asteroid and with some 3-D machines, also delivered and anchored to the asteroid, be able to make the thruster from asteroid materials. The ASIs would have sufficient navigation capabilities to locate the thruster in a favorable position and with gimble capabilities on the thruster, be able to manage its pointing direction. They would be able to make fuel from asteroid materials and communicate to a human station for status and management – perhaps on Earth.

Getting Started:

There are two criteria for a successful asteroid defense: One is to have the asteroid orbit moved out of the Earth-Moon-Mars vicinities, and two is to have this done with an acceptable budget. The Asteroid Control Thrust Strategy presented here meets these criteria.

The two ingredients to meet these criteria are (1) an advanced ASI robotic system, and (2) a capability for ISRU to meet the needs for the ASI robots to do the job.

There are several commercial industries pushing diligently to make a robot for public use on the Earth. Elon Musk, for example, wants to have a personal robot for personal use. Great advances are made each year. Personal robots that also have AI incorporated will have a great advantage, and this will be a high profit activity which will spur continuous improvement. At the same time, in setting up a base on the Moon, it will be a high advantage to use similar robots to establish and maintain infrastructure such as roads, communication infrastructure, and help build habitats and support structures. We will find that robots' operation on the Lunar surface is much easier and less costly than humans. Robots only need to be plugged in for a certain time to refresh energy levels. They may need some extra cosmic ray shielding on various parts and be able to make repairs on space related areas including to repair other robots. This together with space information makes them an Artificial Space Intelligence (ASI) robot. They can learn and grow capabilities and become more and more useful. They would also have a small thruster unit so they could recover from an off asteroid circumstance – discussed later.

They will learn how to make infrastructure that is needed for Mars settlements. These ASI robots will be able to use Mars regolith to make many items needed for humans including food, water, air, fuel, materials to make parts, and machines to do all that is needed. This in-situ Resource Utilization (ISRU) will be vital for sustainability on Mars. They will learn ISRU to do much that is needed to start the Asteroid Control Thruster system on asteroids.

The Asteroid Control Thruster Strategy

A team of say 10 ASI robots could anchor to a NEO asteroid, bringing a small energy solar power system and perhaps a 3-D machine or two. They would analyze the asteroid regolith and make an approximate thruster and fuel for it. They would make adjustable struts for the thruster to be anchored to the asteroid. The thruster would be positioned for the thrust to be aligned to the c.g. of the asteroid and in line with the asteroid velocity direction. Thus, with the thrust it provides it will add a little velocity to the asteroid. As the asteroid orbits the Sun this thrust direction will change and the thruster will be fired only when aligned to the velocity vector. The ASI robots will be able to calculate all that is needed for thruster direction control. This added velocity to the asteroid in its velocity direction will cause the asteroid orbit to grow very slightly - orbit after orbit.

Docking Control

The most challenging aspect of working on an asteroid is docking control. An ASI robot and any equipment can easily fall away if not anchored. One way is to use a masonry anchor or a conical anchor. With these anchors a hole is punched or drilled in the ground, then an insert that is expandable is hammered in the hole, and then a screw device is screwed into the expandable insert. At the top of this insert there is a ring or hook that tethers or equipment can be attached. This is the first operation that the ASI robots would do after assessing approximately where the thruster would be placed (anchored). Another idea for ASI robots to 'hang on' would be to attach a net across the work area so the robots can use the net as handles to move around. There are other ideas for docking control that could be developed in time.

Spin Control

Most all asteroids have some kind of spin – usually a slow spin assumed to be less than one revolution per hour. For asteroids spinning at a higher rate, it may be too difficult to anchor to the asteroid. The asteroid gravitation pull needs to be at least a little greater than the centrifugal force tending to throw the robot away – greatest at the equator. The ASI robot will easily figure this.

It may be a consideration to control the spin of the asteroid for cases where robots can anchor and work. Controlling the spin will make the ACTS more efficient in that they can be fired more often. To do this the thruster could be pointed slightly off the c.g. direction to give a little torque to the asteroid to slow its spin. Another control concept can be 3 orthogonally placed thrusters on high towers and with gimbal capability. Firing these tower thrusters in the right direction and at the right time will yield some control of the spin.

When spin is controlled, the robots could make several large thrusters placed around the asteroid to be fired in succession for increased asteroid orbit growth.

The case of a tumbling asteroid may be more difficult to control. These are asteroids that have combined spin about more than one axis. In this case a different strategy may be needed such as a gravity tractor or a series of impactor projectiles that are done by ASI robots from a nearby controllable asteroid with workable regolith.

Asteroids with no workable regolith

It is considered that some NEO asteroids may have very little regolith or unusable regolith like an all-metal asteroid. In this case where the ASI robots cannot have an ACTS, they may require help from another good regolith asteroid. This can be done by having the ASI robots on a good asteroid supply required infrastructure including appropriate ACTS to be sent to the “bad” regolith asteroid where the ASI team would only do set-up for the ACTS to function and not do any manufacturing of the bad asteroid’s regolith.

Asteroid Orbit change

After the ASI team has set up the infrastructure and tested the system and have control of any spin characteristics needing attention, the ASI team would commence using the ACTS to increase the velocity of the asteroid in line with its orbit velocity. This increases the orbit velocity in small increments around the Sun resulting in a larger orbit. This results in a spiraling out of the asteroid orbit until it reaches the Asteroid Main Belt. At this point the ACTS is shut down, and the ASI robots are also shut down and available for any further directions from the human monitoring system.

However, before the orbit gets too far in its spiral outward, part of the ASI team would proceed to do the following:

1. Duplicate themselves to make another team.
2. Generate a solar power station for the new team.
3. Make a 3-D machine.
4. Make a transfer spacecraft and fuel to travel to another asteroid.
5. Locate and travel to that asteroid with this new infrastructure.
6. Dock/anchor to the asteroid and set up an ACTS to begin this process again.

The first ASI team may also keep making additional ACTS infrastructures and send them to additional NEO asteroids and so on. The target is to eventually move all NEO asteroid orbits out to the Asteroid Belt.

Long Term Outlook

It may be advisable to start the first asteroid with this process with a human crew. They can be flexible to set up an ACTS to see how it would work and to accumulate a knowledge base for the ASI robots to reference. Next the human crew can refine the process for ASI robots to do. Next,

a hybrid team – some humans with some ASI robots, can work to continue to refine the process and include robotic learning. Finally, the humans would step aside and let the ASI robots do most everything.

This start with humans could be a very adventurous build in our Solar System that would inspire the youth around the World to do other great things. It would also promote robotic technology including how to work with robots and learning processes in the Solar System.

After the start with humans, the only cost is a monitoring human team on Earth – i.e. JSC.

Conclusions

The current state of asteroid impact defense is well described in the Kelly Fast presentation given in reference 6. Kelly Fast is the acting Planetary Defense Officer at NASA Headquarters. She describes how the organization was formed, the tasks, various mitigations, and organizations supporting planetary defense around the world. She addressed the NEO Surveyor mission which is planned to launch in late 2027.

We can do much more with asteroids once we succeed with the Artemis program on the Moon and then move on to settlements on Mars. These major activities will advance technologies needed for robots to do much of required work in the space environment to set up infrastructure, build habitats and other support structures, make machines that will gather regolith to produce fuel, energy and most anything that humans need.

These advances can yield an asteroid orbit control as envisioned here. But this is a long-term approach, so it is wise if not necessary to develop two or three other techniques to nudge an asteroid off its course for a near term problem.

The cost of this long-term solution is very minimal since it would only be necessary for human involvement to monitor progress and not do any other “work” after humans get it started in a phased approach.

The advances in robotics with AI can produce a future robot that can accommodate minor challenges as they may have.

We (the human civilization) need to come into a realization that we can do management of Earth’s resources including climate and then come to a realization that we can indeed move from a passive role with space exploration into an active role of controlling the Solar System.

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