ASTEROID AS A RESOURCE

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ABSTRACT

Humanity has evolved on the largest solid body in our solar system, and transporting anything into space is an energy and cost intensive process. So intensive, that if all the materials we have ever launched into space were collected and compressed into a single solid body, it would occupy a region no bigger than a tennis court [1]. Given how expensive it is to lift anything into space from the surface of the Earth, the future of efficient and affordable space travel may be dependent on using the resources that are already up there. Space may seem big and empty, and it mostly is, but there's enough raw material floating around out there in the form of asteroids and comets to keep us going for eons. The trick is going to be rounding these asteroids up and bringing them somewhere they can be of use without spending so much fuel on the process that the effort is rendered pointless. Made in Space is a company that develops technology for, you guessed it, making stuff in space. To gather the raw material for all of our making-in-space needs, Made in Space wants to send small "seed craft" to near-Earth asteroids with the aim of turning them into giant spacecraft that will fly themselves back to Earth to be mined. The basic idea of grabbing asteroids and bringing them back to the Earth-Moon system to harvest their resources isn't a new one. In fact, it's such a not-new idea that NASA plans to send a robotic spacecraft to a near-Earth asteroid and bring a chunk of it back to lunar orbit for study sometime within the next decade. The problem: NASA can bring back only a very, very small portion of the space rock, because asteroids are very, very big, and moving big things in space takes a lot of fuel. (In the case of a big asteroid, an almost impossibly large amount of fuel, especially if you want things done in a timely manner. What Made in Space wants to do with Project RAMA, short for Reconstituting Asteroids into Mechanical Automata, is to make asteroids into self-assembled, self-contained, self-propelled, fully autonomous spacecraft.*

Keyword :- *Cislunar Space, Gravity, Seed Craft, Asteroids, Spacecraft, Orbit, Extraterrestrial*

1.Why Rama?: Mankind has advanced on the biggest strong body in our nearby planetary group, and transporting anything into space is a vitality and cost-serious process. So serious, that if every one of the materials we have ever propelled into space were gathered and packed into a solitary strong body, it would involve a locale no greater than a tennis court. Yet, space as of now contains billions of objects of this mass or more prominent: The space rocks. It has for quite some time been comprehended that tackling the mass of the space rocks and utilizing it to make gear outside of Earth's gravity well would be an empowering agent of the space boondocks. The abuse of space rock assets can possibly change our exercises in space from one of Earth reliance to one of Earth autonomy. Fuel terminals in Cislunar space, expansive scale space fabricating offices, future space stations, and super scale space structures would bankrupt the world if the mass to construct them should have been propelled from Earth, however the cost of these activities all of a sudden end up doable with an accessible supply of space rock assets. The test of the space business lies in the arrangement of meeting these future needs. Global resource consumption is increasing at a rate proportional to both population growth and the rate at which existing populations increase their demand for resources [2] [3]. Transportation organizations giving both up-mass and down-mass must be prepared to deal with the request of transporting the two individuals and gear to and from space. Propelled space producing abilities must be accessible for the development of both huge scale space territories and additionally little scale accuracy parts. Life emotionally supportive networks must progress to completely regenerative status to decrease the requirement for Earth re-supply. Vitality generation and capacity methods must be prepared to give megawatt class control. Lastly, the assets of the close planetary system must be tapped to give simple courses to this development to occur.

2.The RAMA Solution: Made In Space created RAMA to tackle the issue of transporting huge supplies of space rock assets from their common circles to circles of more prominent use in cislunar space. RAMA is a progressive, mass-moderate way to deal with investigate and misuse space assets. The idea depends on a "Seed Craft"; a shuttle which contains actually modern ISRU, Additive Manufacturing, and automated abilities. The Seed Craft utilizes these capacities to change over the accessible materials of a space rock into rocket subsystems including impetus, vitality stockpiling, and direction frameworks. The space rock (now a shuttle in its own particular right) can self-governingly complete an essential mission, for example, movement for less demanding future meet, or to occupy to a more helpful area exhaust space. Then, the Seed Craft which started the change is allowed to plot a course to the following space rock, rehashing the RAMA procedure inconclusively.

3. RELATED WORK AT MADE IN SPACE: Made In Space delivers an inheritance of room producing mastery to the investigation of the RAMA idea. The spearheading endeavors of 3D imprinting in microgravity, starting in 2011 on illustrative research flights and later on the International Space Station in 2014 frame the establishment for the working learning for moving toward the RAMA issue set. All the work at Made In Space is centered around a guide of empowering increasingly to be made in space, so less and less should be propelled from Earth after some time. While the idea of Project RAMA exists on the most distant end of the Made In Space guide, there are numerous projects at present in advance with close term skylines that are empowering to the RAMA vision. The accompanying is a depiction of three dynamic projects at Made In Space; each playing a basic close term advance in empowering the future RAMA mission innovation needs.

3.1 Microgravity Additive Manufacturing: The Additive Manufacturing Facility (AMF) onboard the ISS is owned and operated by Made In Space offering in-space manufacturing as a service to both NASA and other organizations around the world. The techniques developed by Made In Space to enable AM to work in microgravity are key technologies needed to enable the Seed Craft to convert asteroids into spacecraft. The microgravity AM technology can produce parts in a variety of materials from advanced thermos polymers to ceramics and metals.

3.2 Space Resource Manufacturing: Under development at Made In Space are several methods for additively manufacturing products from local resources. This technology is capable of working on planetary surfaces, such as the Moon and Mars, but would be perfectly applicable to an asteroid manufacturing mission. Pictured here is a gear produced using JSC-1A lunar regolith simulant as a feedstock material along with an additive manufacturing technique. The Seed Craft may create gears and other mechanical parts in a similar manner.

4. ASTEROIDS-WHAT AND WHERE?: Any discourse of space rock assets must start with a comprehension of the space rock's arrangement, structure, and circulation all through the close planetary system. The investigation of space rocks is an exceedingly specific and constantly advancing field, however, a general presentation is given here, construct to a great extent with respect to data gave in. Space rock Distribution: Collectively, the space rocks speak to a sum of 3·1021 kg of material, proportionate to ~5% the mass of the Moon, or a solitary body ~1400 km over. The larger part of this mass is contained inside the ~900 km overshadow planet Ceres, and a large portion of the staying mass is disseminated in the principle belt amongst Mars and Jupiter. It is almost difficult to express any widespread administer about space rocks, as their sheer number guarantees that there will be exemptions to each run the show. For instance, despite the fact that the dominant part of space rocks are situated in the primary belt, a huge number exist in Earth-crossing circles that make them significantly more open (and less demanding to distinguish) than the principle belt populace. These space rocks are altogether alluded to as Near Earth Objects (NEOs) and are characterized as any space rock with a base orbital sweep of <1.3 AU. Given their nearness to Earth, NEOs are the most intensely considered, and will probably be the principal space rocks to be tapped for their assets. Because of a persistent procedure of impact and gradual addition that started when our close planetary system shaped (and which proceeds with today), space rock sizes have been smoothed out to take after an anticipated power law. This pattern is delineated in Figure 1-2. As a rule, a space rock of any size is ~100 times more predominant than a space rock 10 times its own size. So if a given locale of a room can be believed to be populated by 100 space rocks with measurements >10km, it is sensible to accept that there are ~1,000,000 undetected space rocks in a similar district with breadths >100m. No thorough adaptive overview has yet been led with the capacity to distinguish space rocks <100m in breadth, and our insight into space rocks of this size is constrained to the little populace that has been identified when one makes a random close go of Earth.

5. RAMA ARCHITECTURE CONCEPT: RAMA makes use of materials found at the asteroid for mass intensive tasks (like providing reaction mass for the propulsion systems), a greater mass can be returned for equivalent mass launched. This is even more true if the RAMA Seed Craft can redirect multiple asteroids in a single mission, either by using the asteroid's propulsive capabilities to redirect itself towards another target before returning, or using the asteroid's resources to replenish the Seed Craft's propellant reserves.

5.1 The Asteroid Spacecraft: The reason for the RAMA rocket is to use a little measure of mass and gear conveyed to the space rock by a Seed Craft and utilize it to restore a bigger mass of space rock crude materials to cislunar space. To achieve this, the RAMA create requires every one of the elements of a customary interplanetary shuttle, subject to the imperatives that they are 1) Manufactured from materials accessible on the space rock, 2) Manufactured on/by hardware accessible on the Seed Craft. The particular arrangement will rely upon the space rock, yet all in all, the RAMA create must have the abilities.

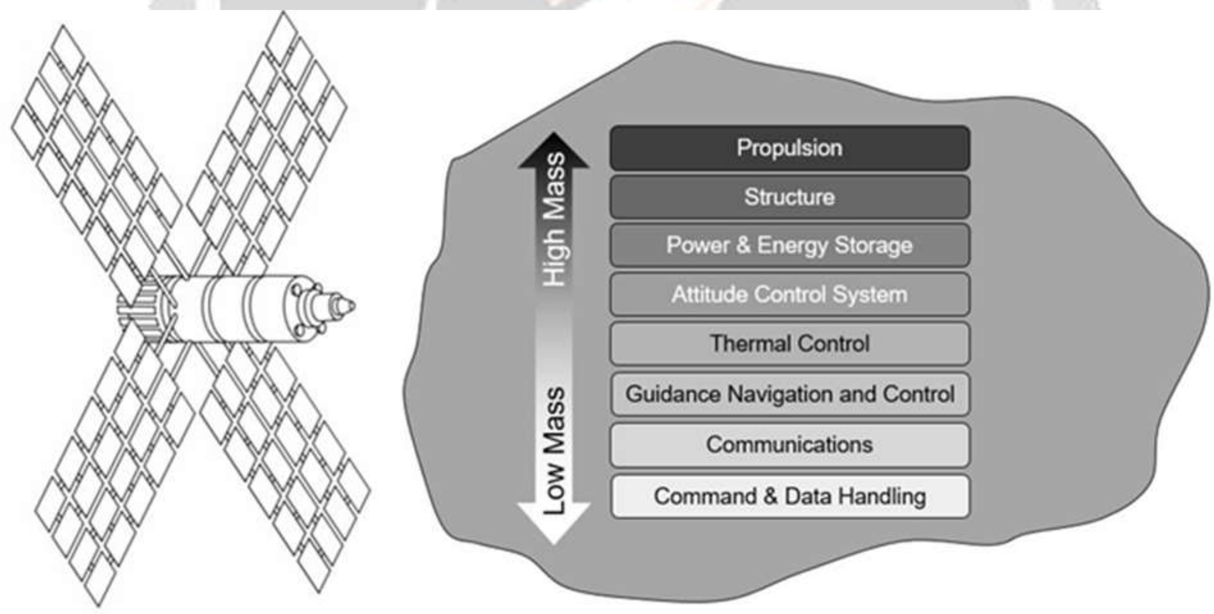

Fig-1: The Asteroid Spacecraft Mass Requirements

5.2 CREATING SPACECRAFT FROM MECHANICAL SYSTEMS: Mechanical and analog devices have been in existence for centuries. Examples of mechanical computing devices date back to 200 BC and were used as navigational instruments in the early days of spaceflight before being superseded by electrical computers. Figure 2-2 outlines eight different mechanical machine examples. The combination of these examples establishes a level of feasibility for constructing spacecraft from mechanical systems. Additionally, research and development in this field has led to analog based 3D printers that require no power or electronics to manufacture a pre-designed object.

5.3: RAMA FUNCTIONAL BLOCK DIAGRAM: The fundamental concept of the RAMA architecture is in the conversion of an asteroid into a spacecraft. In order to do this, the Seed Craft creates spacecraft subsystems out of asteroid materials. For certain asteroid types, material compositions, and mission parameters the best configuration for conversion is to create mechanical subsystems. In all cases studied in this report there are at least some mechanical subsystems that can be made and make sense to make. The Functional Block Diagram (FBD) for an asteroid converted into an entirely mechanical spacecraft via the RAMA process. At the heart of the mechanical spacecraft is a 3D printed analog computer that operates on a series of simple gears. The computer is powered by a store of potential energy found in 3D printed springs and flywheels. Mission objectives for the mechanical spacecraft will be fairly basic in nature requiring simple GNC. Flywheel gyros can be 3D printed and will keep the spacecraft on course by feeding momentum data into the analog computer which subsequently commands the propulsion system to propel asteroid materials and impart course corrections.

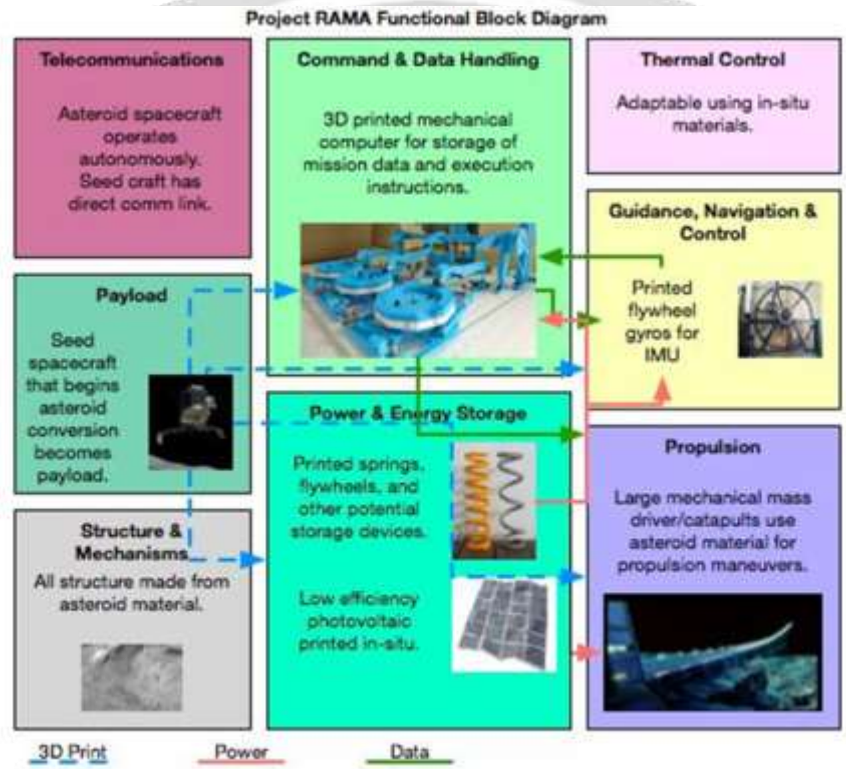

Fig-2: RAMA Functional Block Diagram

5.4 The RAMA Construction Process: The Seed Craft arrives at the asteroid and prepares to dock. The Seed Craft has begun mining the inside of the asteroid while extruding the metallic catapult sling arms. The inside of the asteroid is hallowed out with large fly wheels constructed at the bow, worker drones continue to prepare the inside and outside of the asteroid for its mission. The Seed Craft has completed the construction process and has begun to spin up the flywheels using onboard power .The Seed Craft departs from the asteroid after imparting enough momentum to begin sling arm retraction to the loading position. Step 6, the fully functional asteroid spacecraft begins its maneuver.

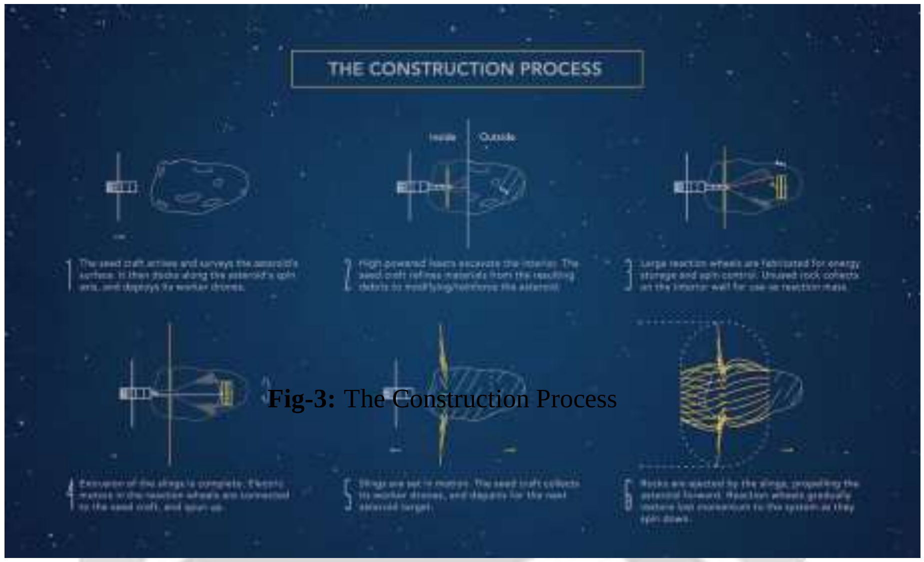

Fig-3: The Construction Process

6. CONCLUSIONS: Difficulties still stay for the RAMA idea to be completely reasonable. There is a requirement for encourage mission improvement to achieve full plan determination of missions that are remarkably suited for RAMA style missions. The significance of doing this is to legitimize the ventures into the RAMA innovation way finished orthogonal space rock recovery plans. Alongside this key test are the difficulties of demonstrating out the capacity for in-situ assembling of mechanical shuttle subsystems. This report demonstrated that a space rock rocket could be produced using in-situ mechanical drive and vitality stockpiling. Propelling these thoughts at a lab scale is a basic subsequent stage. Demeanor control and GNC are two other key subsystems deserving of future advancement as they might be firmly incorporated to the elements of the drive and vitality stockpiling subsystems. Tending to these difficulties, and with legitimate concentration, the RAMA idea will be completely skilled in the following decade, which implies that we could see beginning space rock transformation occurring just 15 a long time from now.

7. REFERENCES:

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