NASAITECH PROPOSAL: PROPULSION / OCTOBER 2016

DEVELOPING AN ANTI-MATTER PROPULSION FUEL INFRASTRUCTURE STUDY

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REFERENCE: LHD-NASA-01-2016

AMOUNT REQUESTED: 1,500,000 USD

ABSTRACT

NASA requires a new approach to propulsion technologies that will provide rapid, efficient long distance space travel between planets within Earth's solar system and beyond, as well as building and sustaining populations off of the planet whether in deep space or on *terra firma*. NASA and space-faring companies and nations will require a lift capacity far beyond what is currently available. This need would be best met with anti-matter based propulsion systems. However, because anti-matter is not readily available naturally nor easily produced, NASA needs to foster the establishment of a national – or global - anti-matter production infrastructure.

This proposal 1) suggests NASA promote the establishment of an anti-matter propulsion fuel infrastructure through planning, programming, and budgeting; and 2) establish a study group to propose potential courses of action, national and globally, to create and establish an anti-matter propulsion fuel infrastructure.

HISTORICAL CONTEXT

There have been many great leaps in technology that were revolutionary rather than evolutionary in nature. The musket was a revolutionary change to how to launch a projectile compared to the bow and arrow. It was not about making a stronger bow or a sharper arrow – but reconsidering the whole concept of shooting a projectile at a target. Similarly, the German V-2 rocket was not just a bigger artillery piece – a larger projectile shot from a longer barrel. It was a whole new concept of how to move an explosive projectile from origin to target. The car did not grow from trying to compel or breed horses to run faster, or adding more horses. And finally, nuclear weapons were not about having a higher quantity of explosives.

Since the 1800's, great leaps in technology have not been only about inventing a single device or vehicle, but about the entire infrastructure or ecosystem of the technology. Today's cars are not merely enabled by four wheels, a steel chassis, and a combustion engine. Rather, an entire infrastructure – and an exceptionally expensive one – exists to support the car including roads, high-capacity bridges, oil extraction and petroleum production, repair facilities, factories to produce cars and their parts, and trained and educated people to perform all of the relevant work. These did not arise in a day, but required a combination of vision and, due to the consumer based nature of the car, demand. I would submit, however, if someone had proposed in its totality the late 20th century car ecosystem in the late 19th century it would have been considered unrealistic at best.

SPACE TRAVEL PROPULSION REQUIREMENTS

The requirement – in the long term – for space vehicle propulsion is to:

1) Lift as much cargo weight as possible off of the Earth;

2) Travel through space as rapidly as possible to reduce deep space radiation exposure times; reduce life sustainment requirements such as food and water; and permit more rapid response;

3) Provide sufficient propulsion power to decelerate at the destination;

4) Provide sufficient lift, as necessary, to escape the gravitational field of the destination planet/asteroid as applicable;

5) As applicable, travel back to Earth at a sufficient speed that reduces time in deep space;

6) As applicable, decelerate and re-enter Earth's atmosphere.

While some space vehicles may be designed to operate as a deep space shuttle only, that is ferrying persons and cargo between orbiting facilities with other vehicles dedicated to conducting round trips between the orbiting facilities and landing on planets or other gravitational bodies, the fuel and propulsion requirements are still applicable but just redistributed across several vehicles rather than a single vehicle.

ADVANTAGES OF ANTI-MATTER PROPULSION

Current space exploration propulsion technologies to enter Earth orbit are based on chemical reactions. Liquid and solid fuels currently in use are in and of themselves heavy. While the amount of fuel required to lift its own weight varies by the type of fuel, it is clear that the quantity of fuel required for increasingly heavier payloads and longer range exponentially increases – in part because as more fuel is needed to lift a heavier payload, more fuel is needed to lift the additional fuel.

An anti-matter based propulsion engine would not need large masses of fuel. With pure anti-matter, an Anti-Matter/Matter (AMM) binary mix fuel core might only require grams of fuel. However, even accepting inefficiencies in the propulsion process and with the AMM fuel itself, the AMM fuel mass should be below ten kilograms for round trip travel to any planet in the solar system.

An AMM engine would, with a small mass of fuel, be able to accelerate to orbital speeds, leave Earth's orbit, rapidly travel to other extra-earth objects such as Mars or the moons of Saturn or Jupiter, decelerate, land, and depart the planetary object, and return to Earth. A trip to Mars with current or near-future technology that would take more than three months might be reduced to a few days. Not only does this make the voyage easier in terms of life support, habitation, and physical health, but it also permits a relatively rapid response to emergencies (need for supplies, health, etc.).

ANTI-MATTER PRODUCTION TODAY

Today, it is clear that anti-matter is produced in only the smallest quantities. Particle decelerators and other apparatuses are required to create various forms of anti-matter, anti-hydrogen being the most common. Anti-matter quantities are produced in such small amounts that, given the cost of the facilities and the energy required, anti-matter is the most expensive substance on earth. The current production rate of micrograms per year leaves humanity far from being able to produce gram or kilogram quantities sufficient for high-tempo and long-distance space travel.

However, it is important to recall that it was not long ago that smart phones did not exist; nor, in terms of human history, cars, planes, or rockets. Indeed, it might be said that humanity is in a better position to develop an anti-matter infrastructure today than it was to build the information computer infrastructure in 1960. The need and technologies for personal computers and mobile devices were not clear then. Today, the need – if not the technologies – for anti-matter is clear.

THE ANTI-MATTER PROPULSION AND PRODUCTION INFRASTRUCTURE

Three main components to realize the goal of having an AMM space travel system are required: the engines themselves, the anti-matter production facilities, and the energy for the production facilities.

Engines

It is simply not possible to design AMM propulsion engines beyond a few theoretical models in the absence of anti-matter itself. However, AMM would require some method of containing the anti-matter in a stable environment so that it does not make contact with matter walls; and then transport anti-matter particles into a matter destruction chamber where it would mix with regular matter to produce an explosive force – much like with conventional rocket fuel. The anti-matter container would probably require some form of magnetic low-temperature entrapment. The anti-matter fuel core itself may be very large in order to generate a sufficient magnetic field and provide sufficient distance between the anti-matter particles and the container surfaces. For example, there will need to be sufficient magnetic force to counter the effects of inertia.

As with any engine design, there are likely several possibilities and approaches.

Anti-Matter Production Facilities

This will be the most challenging aspect of creating the anti-matter fuel ecosystem. As noted above, anti-matter is only produced in small quantities at research facilities such as the European Organization for Nuclear Research (CERN) at relatively high cost when accounting for the staff, equipment and facility, and energy. However, it is essential to note that particle decelerators and other tools to create anti-matter are done so for research purposes. For these research facilities, producing anti-matter on an industrial scale is not the goal, in terms of economics or design.

Considerable research and design would have to be done to create a facility or set of facilities that could produce anti-matter in larger quantities. There could be several approaches to producing anti-matter, some of them currently unknown or untested. It is certain that the first anti-matter "factory" will be expensive and inefficient. But over time, as with all manufacturing and technological processes and products, the production cost per gram will drop precipitously and production will, eventually, skyrocket – figuratively and literally.

Anti-matter production facilities will not need to be limited to any particular geographic location. The anti-matter production center can be located wherever there is a suitable energy source that can generate sufficient energy. Thus, an anti-matter production facility could be beside a massive hydroelectric dam, a nuclear reactor facility, a massive solar array, or other high energy generating facilities.

Energy Sources for Anti-Matter Facilities

Of the three core components of the anti-matter propulsion infrastructure, the energy sources required to power the anti-matter production facilities are the least technically or conceptually demanding, as large-scale energy production currently exists. According to CERN, it takes 0.025 TWh to produce 1 gram of anti-matter – in a perfectly efficient system. However, the current inefficiencies indicate a much higher cost today. According to CERN, it would take 25 x 10^{12} TWh to produce a gram – with current technologies and facilities.

The largest power stations in the world produce at approximately 90 TWh. If all of the energy of one of these power plants was used today to produce anti-matter it might result in at least several grams a year. And while it is true that it is unlikely that the total energy put in will equal the total potential energy created in anti-matter form, net energy savings or minimal net loss is not the goal. The goal is space travel – and to enable in a way that at the present is not possible with current technologies or approaches.

Seemingly prohibitive economies of scale existed at the start or prior to any number of major innovations, such as the car, space flight, computers, and oil production, shipping, and refinement. However, with investments, planning, technology, and knowledge growth over time all of these technologies moved from fiction to fact.

In order to embark upon an anti-matter era, however, we must assess what is needed, and how to obtain it.

WORK PLAN FOR THE STUDY GROUP

Phase I: Assemble a team of experts

Phase II: Draft and deliver a comprehensive study and blueprint

FACILITY/EQUIPMENT: Office space and office equipment. Location TBD.

KEY PERSONNEL: TBD

APPROXIMATE DURATION OF PROJECT: 6 – 12 MONTHS

PROPOSAL CONTACT DETAILS

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