Low Orbit Hydrogen Body Electromagnetic Booster

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Introduction

What if a spacecraft could remain in Low Earth Orbit (LEO) indefinitely? What if the spacecraft could orbit any planet with a hydrogen based atmosphere at orbits just barely out of the atmosphere, and remain there without slowing down and falling into the planet? It would be monumental and would change the way low orbit spacecraft are designed forever. Low orbit satellites would not require refueling. The solution to this problem relies in the abundance and diamagnetism of hydrogen. Diamagnetism or Landau Diamagnetism means that in the presence of a magnetic field, the material will naturally be pushed away from the source. The opposite of this is Paramagnetism that means a particle will be attracted by a magnetic force, and the force that most people are familiar with is Ferromagnetism relating to the transition metals. Hydrogen being diamagnetic means that if hydrogen can be collected and compressed into a more efficient gas, then placing this hydrogen in the presence of an electromagnetic field can eject the hydrogen at high velocities. This produces a prograde force to keep the satellite in orbit for an indefinite period of time. This booster requires only a steady stream of hydrogen, a source of electricity, and various electrical components. It need not be used only in LEO as various other planets also contain hydrogen based atmospheres, as such, the term Low Hydrogen Body Orbit (LHBO) will be used to indicate any orbit that contains hydrogen. The significance of this term not applying only to Earth will be explained in the section “Applications in Other Orbits.”

This booster is not designed to support any heavy payloads in LEO and is mainly designed to support midrange to lighter satellites that remain in extreme proximity to the Earth for communication or monitoring reasons. It can simply be attached to the side of the satellite along with electromagnetic shielding and solar panels. This allows for cheaper simpler satellites that not only require less fuel to reach a higher and more stable orbit, but can use cheaper communication and monitoring instruments to understand the planet. This will become particularly important as larger and unknown planets such as Jupiter begin to become studied with higher levels of detail as it may simply become necessary to study the planets interior from a closer perspective. Again, the crucial aspect of this design is that it does not require a chemical propellant, and that it can recycle hydrogen until the death of the Sun.

It must be noted that this design is entirely novel and originates from a single author, as such all numerical constants given in this paper are assumed to be capable of linear scaling but may require finer adjustment. In other words, due to the preliminary nature of this idea, there is no currently accepted optimal measurements for the design, and as such, the sizes and part specifications are simply to give the reader a better mental picture of the booster. Achieving optimal design of this booster will require many numerical and empirical tests that have not been conducted prior to the writing of this paper and may not be able to be conducted until it is tested in space.

Design

As stated above, the goal of this booster is simply to collect hydrogen present in LHBO, compress it, and then exhaust it at high velocities without having decreased the spacecrafts mass in the slightest. For reasons of mass, the design for the booster is quite simple and requires only 7 major components. These components will be explained in subsequent paragraphs but include: the hydrogen scoop, the hydrogen collection area, two copper coils, two capacitors, and a solar array.

The two passive components of this design will include the hydrogen scoop and the hydrogen collection area. These components do not require any priming and will operate without any outside influence. The hydrogen scoop is simply a large base-truncated cone which will be attached to the front of the spacecraft. This cone will siphon hydrogen from LHBO into the hydrogen collection area. The most efficient and safe angle for cone will have to be determined experimentally as there are currently no known equations to accurately predict the friction coefficient of individual atoms on a surface. For visualization purposes, it is hypothesized that a dish measuring 3 meters in radius at a 35 degree slope will be sufficient for capturing hydrogen in LEO. These dimensions will vary drastically depending on the environment in which the booster is placed. As the hydrogen atoms enter the collection area, the monatomic hydrogen (Braun, 2012) will bond and become diatomic hydrogen ($2H \rightarrow H_2$). This collection area is another truncated cone measuring 10cm in length, with an opening diameter of 5cm and an exiting diameter of 3cm. This holding area serves the dual purpose of not only holding the hydrogen until it can be expelled in one great boost, but it allows for the density of the gas to be increased via the electric coils. This density increase increases the diamagnetism of the gas and thus, the efficiency of the booster in a direct relationship (Vignale, Rasolt, Geldart, 1988) (This paper describes dense electron gases but the relationship to density can be assumed remain in diatomic hydrogen with a different coefficient).

Surrounding the hydrogen collection cone, there are two coils, each of which serves a similar but unique purpose. Both of these coils are placed near the head of the collection area and will only serve to “push” the hydrogen out of the collection area at high velocities. When the collection area has been determined to be sufficiently full of hydrogen, the first coil will fire.

This firing signifies that a capacitor is discharged into a copper coil at a high amperage which in turn, produces a magnetic field. This coil will be on for a prolonged 3-5 seconds and will compress the hydrogen into an even denser gas. The capacitor voltage drop equation is $(\Delta V)(1-e^{(-t/T)})$ with V being voltage, t being time, and T being the circuits time constant (Kuphaldt, n.d.). This means that the second coil should fire before the first capacitor has been fully drained in order to prevent the hydrogen from reexpanding. This second capacitor will fire which will open a small hatch on the bottom of the collection area, and then trigger the second coil. This second coil and capacitor will serve the purpose of accelerating the hydrogen and propelling the ship forward. As such, it should be expected that the second capacitor and coil will be multiple times as powerful as the first coil and the total fire time of the second capacitor will be less than 100μs. This system of two capacitors and coils may at first seem quite complicated, but it will dramatically increase the diamagnetism of the hydrogen gas before the second coil is charged, and will thus allow for a significantly more efficient propulsion, not only in energy used but in how much hydrogen is wasted.

The final major component of the design is the solar array which should not be expected to be quite complicated or large at all. In most orbits, and particularly in LEO, the collection of hydrogen will take far longer than the collection of electricity. As such, there should be no issues on that side. Depending on the mission, it may be possible to operate the booster on excess power from the main satellite alone. To get an image of the capacitor designs, it is currently hypothesized that the optimal first capacitor will be 300V with a capacitance of 1/2F and the second capacitor will have approximate values of 500V with a capacitance of 15000uF. These measurements are not set in stone and are designed to give the reader an understanding of the different characteristics of the two capacitors.

Possible Points of Failure

This design of a renewably powered LHBO booster has two main possible points of failure. In the event that either of these events come to pass, it could result in the destruction of not only the booster, but the satellite that it is holding up. The first of these is the more simple and unavoidable case of space debris which will puncture the hydrogen collection cone with any ease that can only be described as being akin to throwing a rock through a sheet of paper. As such, the hydrogen collection cone should be supported to the end by a minimum of 4 thick support rods in order to minimize the total destruction of the cone. Though, it space debris may still puncture the cone and it should be assumed that the hydrogen collection cone will have eventual performance degradation and possibly failure although it is difficult to say with any accuracy how long the cone will last.

The second possible issue is one of design and insulation. During the firing of this booster, there will be large electromagnetic current spikes that may have mission endangering effects. The first of the two is the creation of the prolonged magnetic field as a result of the first coil. This may interfere with scientific sensors as it could increase the base voltage of the satellite. The second and far more disastrous problem arises in the firing of the second capacitor into the coil which will produce a large electromagnetic spike and may damage or disturb electronics that are placed too near to the coils. This risk can be mitigated through the creation of a faraday cage surrounding the coils (Chandler, 2011) and through slower but more reliable space-grade chips (Whitwam, 2014). Both of these electronic problems may also be mitigated through shutting off the cpu and all monitoring equipment during the firing of the booster. While this will not prevent the possible destruction of the chip, it will at the very minimum prevent the chip from spitting out incorrect information or having any of its bits flipped, both of which could be catastrophic in the event that highly rare data was collected during the firing and it would then be unknown whether the data was reliable.

Applications in Other Orbits

This booster is designed to have the most immediate impacts on the LEO region of Space as that is currently the most easily accessible location in space. As such, it makes sense to experiment with this design and to commercialize it for Earth purposes before it is expanded into the Solar System. But in terms of applicability, the gas giants, Jupiter, Saturn, Uranus, and Neptune (Howell, 2018) all present fantastic opportunities for the application of this design. That is why the booster is called the LHBO Electromagnetic Booster because it should be able to function on multiple planets where it may have even more impactful effects. Each of the gas giants contain atmospheres of hydrogen and all of them are so far from Earth that refueling or providing orbital boosts is uneconomical. If study is to be conducted on these planets in a low orbit, the satellites will require a fuel source. As such, a booster that does not run out of fuel is something extraordinary handy. In addition, due to the larger atmospheric hydrogen contents on these gas giants (Howell, 2018), it may be possible that larger boosters can be designed to support even heavier satellites and even possibly stations containing humans.

Another part of the Solar System that may truly benefit from this technology is satellites that orbit the Sun at close distances. While no current satellite orbits close enough for this booster to be relevant, the Parker Solar Probe is expected to enter the outermost layer of the

Sun’s atmosphere and is set for a 2018 launch date (Strickland, 2017). Satellites such as these require thick shielding and may have the mass to remain in orbit for extraordinary long periods of time, but it still may be beneficial to have altitude control of the probe to explore different regions of the Sun’s atmosphere. Due to the Sun’s solar winds, it should be extremely simple to collect sufficient hydrogen to perform altitude maneuvers with the booster, with the most important benefit being the production of no heat. While this may not seem of the utmost importance, being able to produce acceleration without heat is a massively beneficial tool for near-Sun satellites where heat-management is of the utmost concern.

Conclusion

The creation of a booster that operates solely on elements present in its environment will revolutionize space exploration. Cheaper satellites and satellites that are closer to the surface of planets will allow for better understanding of our Solar System and will help progress space exploration. Right now the concept for this booster is preliminary and will require serious optimizations in the collection and compression of the hydrogen, both of which are critical in order to improve the viability of these boosters in LEO. Other planets such as Jupiter will be far easier to implement a hydrogen diamagnetic booster into a spacecraft, but the first steps must be the commercialization and the spread of the idea of a booster that can keep satellites in stable orbits and does not require chemical propulsion. Chemical propulsion will run out and is a liability for long term stability, a hydrogen booster has no such problem as it simply collects the materials it needs to remain in orbit. In the event of a catastrophic failure, it may still be possible to revert to chemical propulsion, but that is not the purpose of this design.

There are discoveries that would increase the efficiency and viability of this design multifold and those would be the creation of paramagnetic hydrogen or metallic hydrogen. Paramagnetic means that it is attracted rather than repulsed by the electromagnetic field and this is what Bohr's model of the atom predicts (Ashworth, 1920). Metallic hydrogen would have a much greater effect but is a significantly more challenging problem as it requires large pressures and has only been created a single time using pressures of 465-495 GPa (Macdonald, 2017). As time progresses, other discoveries will be made that may improve on this design, but as of right now, using hydrogen density data provided by NASA and some generous efficiency estimations, it can be predicted that the design would function at distances similar to the altitude of the International Space Station (ISS). Though it may prove beneficial to have the satellite orbit even closer than the ISS in order to increase hydrogen throughput. Of course, depending on the mission, it would be possible to simply have a larger collection area to provide for higher altitudes. These calculations have not been included due to the rough nature of the numerical coefficients but should any reader wish these calculations they will be provided upon request.

In conclusion, the point of this paper is not simply to design a booster. It is to design a booster that accomplishes an unaccomplished goal. This booster would allow for spacecraft to sit in cheaper and more closer orbits than ever before and to remain there indefinitely. Lightweight satellites can be shipped up and can be expected not to drift towards the Earth. This could allow for a variety of long term cheap scientific monitoring satellites that constantly stream information from close to the Earth. It will open the gateway to installing LHBO satellites that do not require maintenance or adjustment. Satellites that will remain in orbit until they are physically destroyed without refueling a single time.

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