Progress on Electric Space-Thruster for Single Stage to Space and Planetary Defense.

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ABSTRACT

Analysis predicts that an ion rocket using moving electric fields can deliver high, controllable thrust while remaining a fully electric, non-explosive technology aligned with peaceful uses of outer space. This architecture supports multiple applications, including surface hovercraft, single-stage launch vehicles, and theoretical interstellar vehicles using “warp-like” capabilities with conceptual, internally recyclable reaction mass for sustainable long-duration flight. High thrust can be applied to planetary defense by deflecting hazardous asteroids, offering a non-nuclear option. In addition, the thruster can be reconfigured in flight to enable single-stage-to-Moon transits, supporting early geo-lunar industrialization and safer, more routine human access to cislunar space. The presentation will report the latest proof-of-concept hardware status, initial test plans, and applications.

PAPER

1 Faster access to space for all

This rocket technology is based on established physics, and can be built by anyone, anywhere. It is inexpensive, reusable, and does not require explosive fuels. It uses environmental molecules as reaction mass, similar to an airplane propellor, so there is no need to carry reaction mass. It supplies tremendous, controllable thrust, according to the published calculations. It provides propulsion in all aerospace applications: for terrestrial hovercraft, aircraft, and space travel. It could spark a new technology increase, like the automobile or the first aircraft. The only thing left to do is to see if it works. To that end, the effort described within is proceeding to create the first proof-of-concept prototype to see if it can produce thrust. If it does, it will provide a great leap forward for all in terms of access to space. It can provide human-survivable, 1g, access to Mars in 1.7 to 5.7 days, and to the Moon in under an hour or to the nearest stars in well under ten years. Certainly, it would provide access to the asteroids, and serve as an effective means to deflect Earth-bound asteroids.

Calculations[1] show that a one-meter-long engine of this type can produce thrusts far exceeding the 35 megaNewton thrust of the Apollo Saturn V rocket. But great claims like this require great proof. The prototype has been 40 years in the making. The initial concepts happened back in the 1980’s, and waited 37 years to start the main design, to avoid any invention issues with my aerospace employer. The deep analysis of the possibilities began in 2024, indicating a possible thrust of 29.6 zettanewtons. The benefits to humanity from such a rocket were too enormous to ignore, and a proof-of-concept prototype effort was started, and continues, with the latest progress leading up to the upcoming experiment, ideally occurring in 2026. If the results are positive, then by 2030 the technology should be available and producing results for humanity, and our expansion into space will be accelerated.

2 High thrust ion rocket, H-Drive

This rocket uses ions for propulsion, but does it differently than the general ion thruster in use today in that it performs more like an inverse mass driver than as an ion accelerator and emitter. A mass driver uses electromagnetic forces to pull magnetized mass buckets forward and send their payload flying into space[1], this rocket pulls on the molecular mass to move the whole engine into space. I built a mass driver in 1983, and some of the knowledge built up in that effort is applied to this technology.

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[1] Personal conversation with Dr. Gerard K. O’Neill

The main difference between this ion engine and conventional ion engines is that instead of accelerating ions out the back of the rocket, this electric engine pulls on the momentum of charged ions, electrically. There is a non-zero amount of motional force to be obtained from the momentum of individual ions through the Coulomb force. The charged electrodes in the engine attach to each ionized molecule through electrical lines of force, and there are many molecules in an ion cloud.

The other major difference is that conventional ion engines exert a continuous acceleration of the reaction mass, launching it in a continuous stream out the back. This engine has a repetitive application of thrust; a million times per second is the design limit of this prototype, where a ‘fluent’ runs down the engine tube moving the electrical charge on the electrodes in the engine tube from the front to the back, similar to the moving magnetic fields in a mass driver. The engine is the mass that is driven. The engine crawls up the molecular mass like a canoe being paddled in the water. Each fluent supplies another pulse of force, linearly multiplying the force per fluent. The fluent repetition rate is adjustable underway to adjust to the prevailing environmental conditions and to accelerate, to vector the thrust, and to best control the momentum of the ions. The electrodes are charged using physical electronics and they have speed limitations, so jumping levels in the electrodes allows conventional electronics to keep up at higher speeds. The highly-synchronous electrode firings are controlled with precise accuracy to produce the desired fluent on the engine tube. They are meticulously adjusted and monitored in flight.

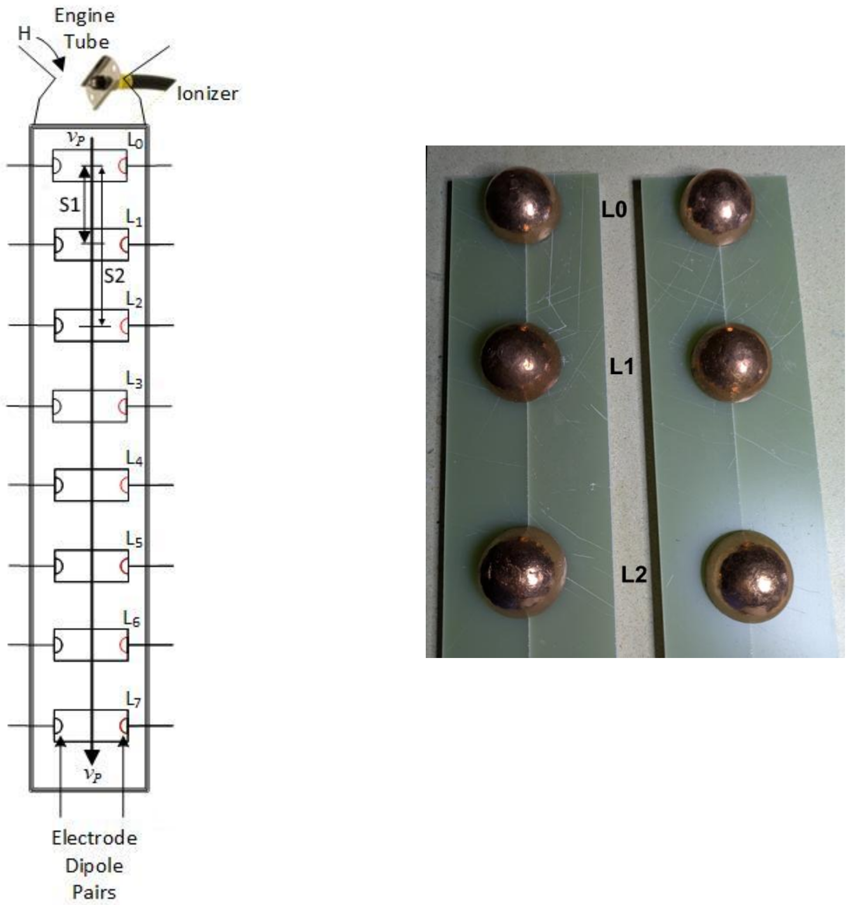

Figure 1. In an Engine Tube, shown on the left with eight levels of electrode pairs, molecules enter from the front, hydrogen in this case, get ionized, and a fluent pulse transits down the engine at velocity v_P. In a warp maneuver, the distances between electrode levels can be increased from S1 to S2, by skipping levels, to allow faster speeds to be reached. On the right, three levels of copper half spheres make up the prototype electrodes.

Three electrode levels are being used in the prototype, and only two electrodes per level to save costs and production time. The name ‘H-Drive’ was coined for this electric engine because the engine performance was calculated in terms of hydrogen constituents in the ion cloud and because the electrical circuit across the pair of electrodes makes up an H-bridge circuit, with the engine tube in the middle, as seen in Figure 2.

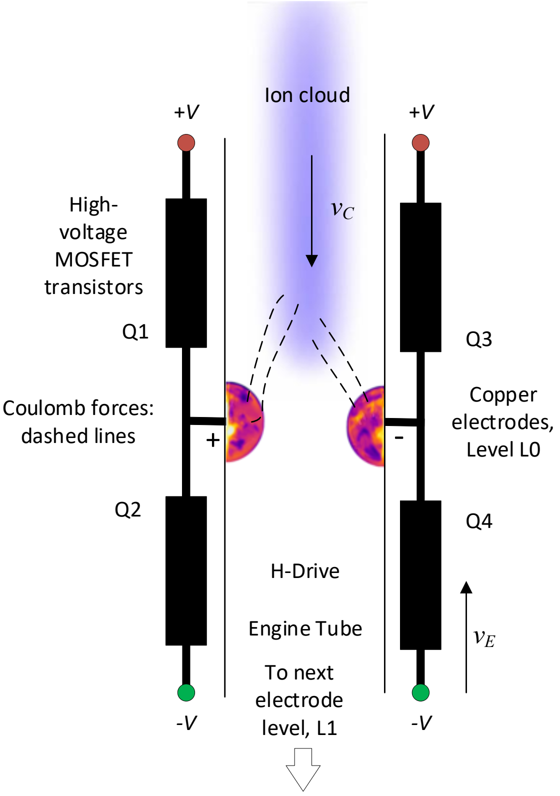

Figure 2. The H-Bridge circuits of the H-Drive are being built for the proof-of-concept prototype. It forms a H, with the electrodes in the middle, producing a 'dipole field'.. v_C is the velocity of the ion cloud and v_E is the engine velocity.

2.1 Relativistic molecular mass increases

The fluents run down the engine tube, energizing electrode set after electrode set to draw against the ion cloud. The fluent patterns, relative to the ion cloud velocity, may be run at relativistic speeds down the engine tube. Existing electronics already have signals that run near the speed of light, so with careful timing, this is possible. The Lorentzian mass increase, seen in Figure 3, is expected to provide higher levels of momentum in the ion cloud for the engine to pull against.

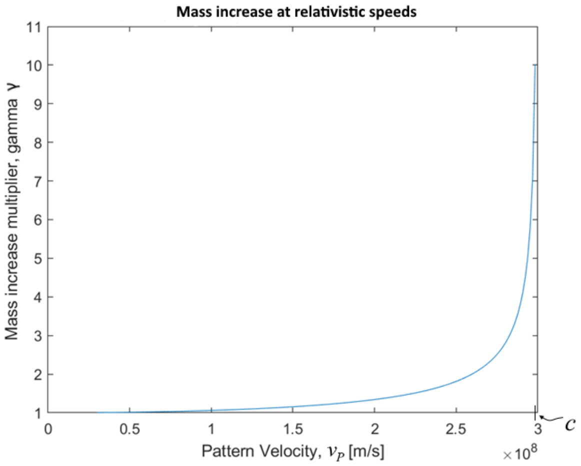

Figure 3. Relativistic mass increases inside the engine occur as the internal fluent pattern velocity running down the engine tube approach the speed of light, c, in this case at 0.999% of c, increasing the molecular mass 11 times.

2.2 Predicted performance

Ion rockets in 2026 generally produce thrusts of less than 10 N (Newtons) and expel reaction mass to move. This electric engine design is calculated to produce immense thrust, theoretically to 29.6 ZN (zettanewtons, 10^{21} N) for a 1-meter-long engine. The calculations and physics are shown in the referenced

AIAA paper. The rocket uses Coulomb, atomic, electronic forces instead of chemically-derived forces, and is calculated to provide 10^{15} times more force than the Saturn V Apollo rocket. Because of these interesting thrust predictions, the prototype is being created to see what thrust the engine may actually produce.

2.3 Rocket Architecture

At the time of this writing, the theoretical design has been reduced to engineering practice using current technology, with no exotic materials required. The initial rocket system architecture and physical parameters have been determined.

The control and power circuits have been tested and are being developed into a working unit. Circuit cards to drive the electrodes to control the electrical fields are in process, and the infrastructure is being built to conduct the experiment, including power supplies and accelerometers to detect any motion.

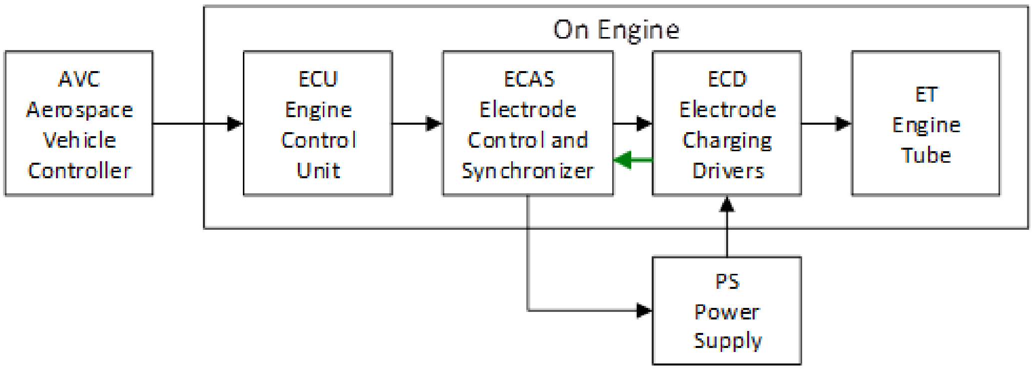

Figure 4. Rocket driver architecture. The ECAS runs the fluent pattern

2.4 The experiment

The prototype H-Drive engine is being constructed, as shown in Figure 5, suspended inside a Lexan housing, the birdcage, where it will not be influenced by outside air motion. Any motion should be due to the action of the H-Drive on the atmospheric molecules.

. An engine tube with three levels of electrodes is suspended from the top of the Lexan enclosure, the birdcage, so that it can swing when it is accelerated by the action of the H-Drive. Acceleration pulses will be measured by a small accelerometer mounted on the engine tube. Sustained thrust will be measured by the laser time-of-flight sensor as the thrust produces an offset in position for the suspended engine tube.

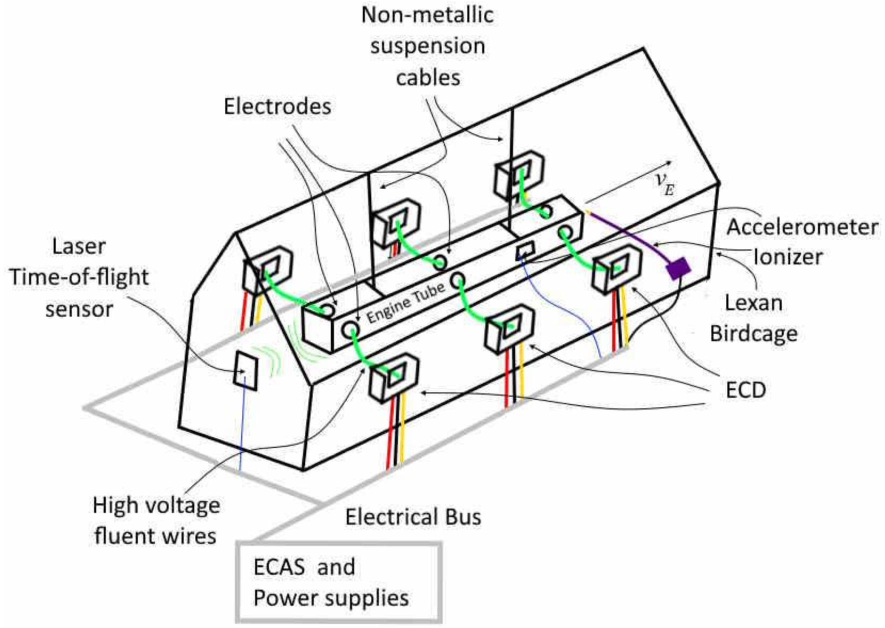

Figure 5. This is the planned prototype system. The engine speed is v_E. The change in $v_{E,}$, the acceleration will be measured.

All electronic parts can be purchased off-the-shelf except for the Electrode Charging Drivers (ECDs), for which a printed circuit board is being created. The ECD circuit has been designed and tested. A prototype ECD is being built and tested at high voltage. The current state of the ECD circuit board is shown in Figure 6. All components for six cards are ready, as are most of the other components for the prototype shown in Figure 5. Now time and effort are the main limiting factors leading up to the experiment.

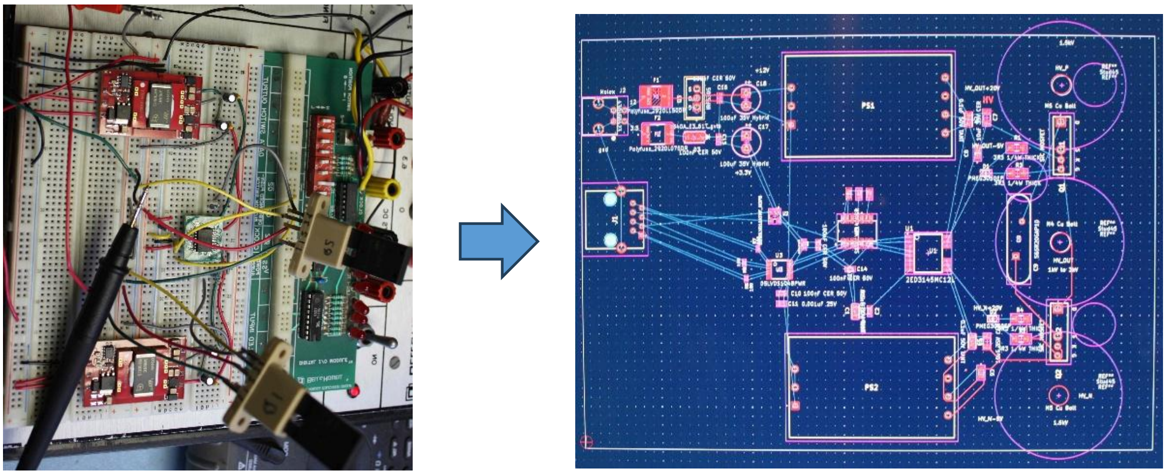

Figure 6. The ECD printed board design is nearing completion. The working 'breadboard' on the left is being transformed into a printed board, capable of switching the high voltage to the electrodes.

Further information on the technical details of the progress of the H-Drive can be found in the newsletter[2] listed in the references.

3 Peaceful uses of the electric engine

This technology will be easier to get running than chemical rockets, and you can build one in your garage to make your own hovercraft, for instance. You just would need the controllers, the electrodes which you can make, and electricity. A high voltage power supply is also needed. It will be interesting to see what people come up with.

With an engine such as this, theoretically capable of reaching other star systems in our lifetimes, humanity can expand across the galaxy, potentially reducing the need for wars on our home planet. This technology can be developed by all peoples, achieving the goal of helping consciousness survive because it is distributed, instead of being localized on one planet only.

Figure 7. Our new homes.

In a space-to-space application, the engine can charge power banks from solar energy, waiting to be used as a ferry between locations in space where the sun supplies enough power. In the development of geo-lunar civilization and industry, having a dependable transport vehicle that does not need refueling and is capable of immense thrust is good. In terms of fueling, higher payloads needing to get to a destination fast may add additional hydrogen to provide more traction, providing additional horsepower to get moving, supplementing the molecules in space. Various aspects and applications of the H-Drive technology are described in the following sections.

3.1 Non-explosive technology

In the electric engine there is:

- no oxidizer or chemical fuel required,
- no cryogenics except for superconductors to help charge the electrodes, not for liquifying fuel
- no igniters,
- no nuclear-pusher explosions,
- no propellant loading
- no test-fires at the pad using explosive chemicals

The only environmental impact may be ionization of the surrounding molecules using electricity, like what happens in a lightning strike. The ionization should quickly fade into stable, neutrally-charged molecules. This makes it safer than chemical rockets and useful for personally-owned vehicles, such as flying cars.

3.2 Surface hovercraft, VTOL

A vertical takeoff or landing (VTOL) aircraft would use the engines like a multi-propellor drone does to lift using multiple engines as shown in Figure 8. If operating on Earth, where there is an atmosphere, lifting wings as in conventional aircraft could be employed to reduce the energy required versus a straight vertical lift. The number of engines could also be reduced by using thrust vector control, by energizing electrodes from different levels.

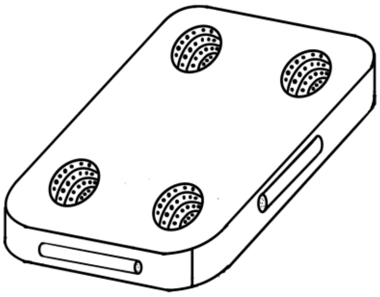

Figure 8. VTOL hovercraft or lifter. Motion is provided by horizontal H-Drive thrusters.

Portable power packs should be developed as time goes by, to support the electrical demands of this lifting technology for hovercraft, using thrust-vector control or geometrical multi-engine mounting like on propellor-driven drones. There is ‘no free lunch’, and to hold an average person off the ground would take approximately 700 N of thrust and about one horsepower to lift them initially.

3.3 Single-stage-to-space launch vehicles

The engine will have to move between different domains and speeds as it lifts off the planet, where there is a high concentration of molecules in the atmosphere, to space, where the molecular concentration is much lower. It has been calculated that the hydrogen concentration in space is sufficient to support the thrust generation, and if the relativistic aspects of the molecular mass increase works, the reaction mass will be increased, providing greater acceleration.

The internal configuration of electrodes in the engine tube can be changed during flight, skipping levels of electrodes as the engine speed increases, so as to ensure that the engine can maintain a certain fluent speed versus ionic cloud speed internal to the engine tube. This is especially important if the fluents are operating at a certain fraction of lightspeed, so that the Lorentzian mass increase of the molecular momentum is steady and constant. The ship will still perform even if the expected relativistic mass increases do not appear.

The launch vehicle is reusable. It does not required externally loaded, or explosive propellants, and may be left in space for space-to-space transport, or as a descent vehicle to Earth.

3.4 Solar System operation

If the acceleration of the engine is controlled such that one Earth gravity is steadily obtained, it should result in a safe ride for human passengers. The trip to the Moon could be accomplished in under one hour, and Mars could be reached in 1.7 to 5.7 days. The ship accelerates at 1g half of the way there, and decelerate at 1g the other half of the way. Deceleration can be accomplished by reversing the fluent direction in the engine and turning on an ionizer at the other end.

Jupiter could be reached in less than 10 days. Payloads that can withstand higher accelerations could get there much quicker. It is conceivable that massive numbers of passengers could be lifted into space at once, based upon the calculated, massive, potential thrust.

A single-stage-to-the-Moon rocket uses different warps to rise off Earth, operate in geo-lunar space and land directly on the Moon, perhaps adding additional hydrogen to the ionizer for final descent. The engine is highly configurable in flight, and can be used for space-to-space applications after bringing the payload to the Moon.

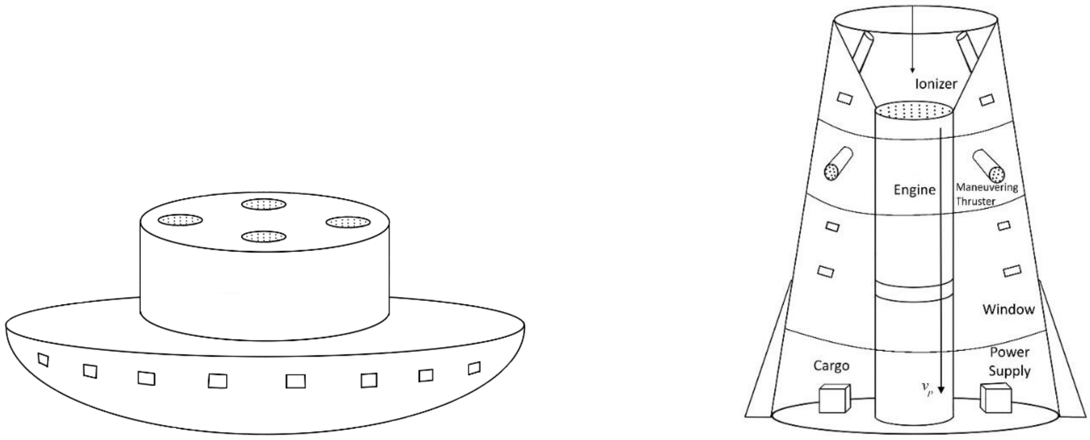

Figure 9. The leftmost spacecraft would be for sightseeing, space tourism, or as a single-stage-to-space vehicle, likely for use in the proximity of Earth. The spacecraft on the right uses a single engine with thrust-vector control for transit throughout the Solar System. Spacecraft can also be designed for higher-acceleration transits for payloads that can withstand more than 1g.

Theoretical interstellar vehicles

The nearest stars could be reached in under 10 years, a trip across the Milky Way galaxy in 10 to 20 years, or to Andromeda in approximately 28 years, at 1g constant acceleration and deceleration. At some point in this constant acceleration to distant regions, the ship would approach the speed of light. There does not appear to be any physical impediment to crossing that barrier, based upon the thrust-producing mechanism, but relativistic and other issues may arise at that point. The ship is made of ponderous matter, not a vibratory waveform, like light. We shall see if the rocket works, and then take it from there.

Because the engine pulls on ionized molecular matter, instead of expelling it, once the pull has been performed, there is no need for the molecular cloud to be separated from the engine. It does not need to be thrown out the back as thrust. It seems that it may be gathered back up and recycled with a large molecule collector, as shown in the rightmost drawing in Figure 10.

Changing the configuration of the fluents and the selection of their electrodes is termed a 'warp'. Changing warp levels could be dramatic, and needs to be conducted safely; it is similar to changing the transmission gear in an automobile.

Warp levels are changed to accommodate higher engine speeds. There is a space-time relationship between the firing of each level of electrodes in the engine tube. If the electrodes are placed one set every meter, and you fire them one after another at a millisecond rate, but then switch to firing every other electrode set, i.e. two-meter separation, at the same one millisecond rate, you will have twice the speed of fluents down the engine. So, as you accelerate, and cannot fire the electrodes fast enough to keep up with the needed acceleration, you warp the engine, you stretch out the distance between the electrodes that fire so that your electronics can keep up with the desired velocity.

A Bussard Ramjet[3] could be used to gather molecules for reaction mass in deep space, by spreading out a multi-km funnel in space ahead of the rocket. Calculations based on predicted interstellar hydrogen density, show this may not be required, especially if relativistic molecular mass increases can happen. The Bussard Ramjet has a magnetic cone with a mile-wide opening, funneling molecular hydrogen into the H-Drive opening, as shown in Figure 10.

Conceptually, the engine can re-use the ion cloud exhaust after it has passed through the engine, especially if the Lorentzian, relativistic, mass increase of the molecules in the engine tube can be achieved, since the ions left behind after the engine passes would not have the same relativistic mass increase, and would be less massive. Either way, the momentum of the ion cloud is being clawed at with Coulomb forces, not expelled out the back of the engine for Newtonian force production. No doubt they are all related, but it appears that, as long as ionic molecules were available for the engine to attract, then they have played their part, and could be collected and reused.

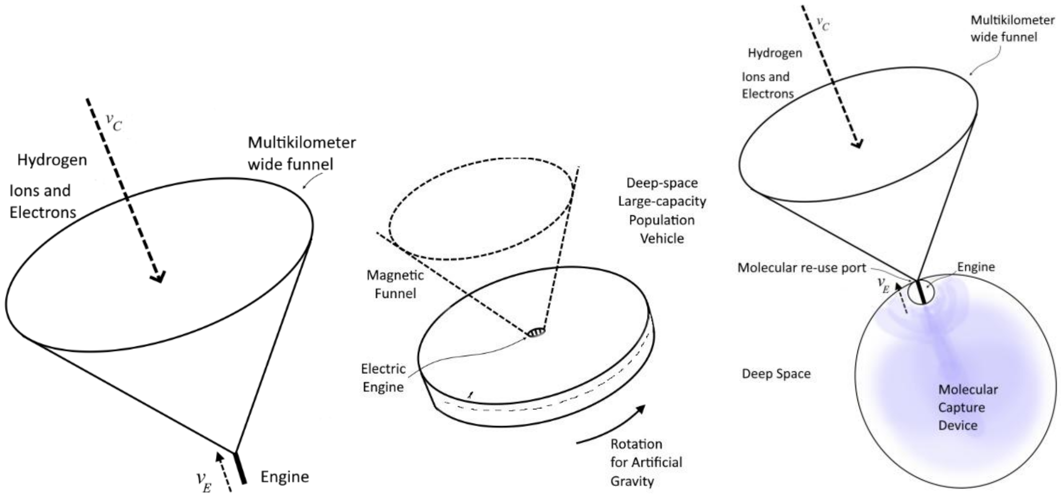

Figure 10. Three instances of deep-space craft, the leftmost has a Bussard Ramjet to gather more interstellar molecules to use as reaction mass. The middle ship attaches a large, spinning, artificial-gravity human enclosure for longer trips. The rightmost one adds a molecule catcher to permit recycling of reaction mass.

3.5 Geo-lunar industrialization

Geo-lunar industrialization will be enhanced with the ability to lift greater payloads from planet Earth. These payloads can be engineered to withstand higher g forces, enabling faster transit to their destination amongst the local space rocks or to colonies at Lagrangian points.

The vertical lift of these engines will work on the moon also, and may be useful in lava-tube mining, to bring raw materials to a mass driver for launch towards a mass catcher at a lunar libration point. These mass catchers can also be driven by H-Drives to move to the correct locations in the ballistic intercept zone to catch the payloads. They can then carry the masses to an orbital depot for processing.

3.6 Planetary defense

The massive thrust that the H-Drive can produce will be useful in deflecting hazardous asteroids, or even mining beneficial minerals from the asteroids. To perform a deflection, the engine would grab the asteroid, and pull it. An ionizable starter gas may be used to increase the thrust by making an ion-dense region for the engine to pull against. The density of hydrogen in space will allow operation, but more hydrogen is available to the engine when it runs at higher speeds. In this case, the rocket will be starting from a more ‘stationary’ position, and we’ll want to give it the best ability to generate massive thrust to deflect the asteroid.

This capability presents a non-nuclear method to move hazardous near-Earth objects away from us. They will not just burst into fragments, but instead be sent on a long-term trajectory into empty space. It may even be useful to just grab the asteroid, and reposition it to a safe trajectory, while we mine it for whatever it has.

These engines will stay in space, ready for fast motion towards near-Earth objects such as asteroids, meteors, and space debris to deflect them into safe trajectories. With the massive thrust of the engine, these space hazards can be sent out of our solar system, and the engine brought back for the next planet-saving encounter. In between saving the Earth, these space engines can be used to remove space debris, attaching a debris net, and hauling the refuse to some space recycling station for re-use.

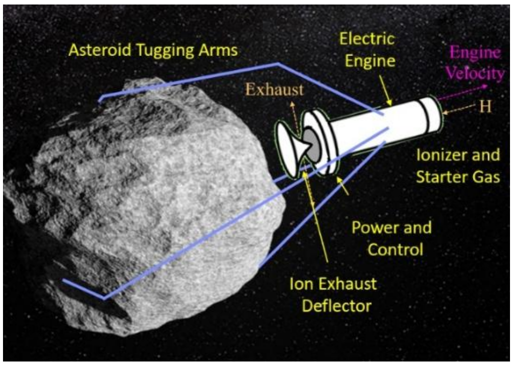

Figure 11. Asteroid deflection or retrieval.

3.7 Human spaceflight

Human access to geo-lunar space will become routine, inexpensive, and safer. These rockets are completely reusable, and consume no fuel except the electricity to run the H-Drive. Safety is improved because they are non-explosive.

The development of this rocket prototype provides hope that our expansion into space will be successful, making us a multi-planet species, even a multi-star species. The high levels of thrust that are calculated for this engine seem to be immense, but are what would be required for true expansion of civilization into multiple star systems and across the galaxy. It is a step in our direction off-planet, and will at least be one data point in finding out what works. At most, it will kickstart our civilian space program, and all others, in the same way that learning to fly or drive automobiles changed our civilization tremendously. It will accelerate space tourism; colonies on Mars, the Moon, and deep-space O'Neill-type space colonies; protect our planet from space debris; and remove the need for highly-expensive, exquisite space-vehicle development programs, when the effects can be created in one's garage.

ACRONYMS

Acronym	Description
AVC	Aerospace Vehicle Controller
ECU	Engine Control Unit
ECAS	Electrode Control and Synchronizer
ECD	Electrode Charging Driver
ET	Engine Tube

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