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Terrestrial and space applications of gravity-like fields: A designer's perspective

Abstract

Extended Heim Theory (EHT) suggests two additional gravity-like fundamental forces and proposes the possibility of propellant-less propulsion for space flight. If sufficiently safe and cost effective, technology spinoffs may prove to be disruptive for terrestrial applications. Applications based upon advancements in this field could have far-reaching implications for transportation, architecture, urban planning and industry. Coupled with promising distributed energy technologies of sufficiently high specific energy, the impact upon local economies, social systems and even representational democracies may be a challenge to future generations.

Keywords

Gravity; Gravity-like; Gravitomagnetic; Architecture; Transportation; Heim.

INTRODUCTION

In July 2005 the paper "Guidelines for a Space Propulsion Device Based on Heim's Quantum Theory"[1] detailed a hypothetical mechanism for propellant-less space propulsion through the generation and manipulation of gravity-like fields. The paper, by Walter Dröscher and Jochem Hauser, was based upon an extension of Heim Theory developed last century by physicist Burkhard Heim. Marc Millis, the former director of NASA's Breakthrough Propulsion Physics (BPP) survey, wrote[2] in January 2006 of the prospect of generating gravity-like fields for space propulsion, stating that the mechanism described, though interesting was "in such an early stage of development that it is premature to judge its viability."

Subsequent articles by Hauser and Dröscher, including the recent Chapter 11 of *Gravity-Superconductors Interactions: Theory and Experiment*[3] have built upon their original proposal detailing the conversion of photons into a gravity-like field and a quintessence or vacuum interaction with the conversion of photons into a repulsive gravity-like field. That chapter concludes with the statement from the authors that "Gravity-like fields most likely would lead to novel technologies in the general field of transportation, and thus should be of major interest to the public and, in particular, to industry"; continuing that these "completely new technologies, [are] comparable to the advent of electricity and magnetism in the 19th century."

The concepts presented within what has become known as "Extended Heim Theory" (EHT) are speculative and still await confirmation. EHThas yet to reach the status of a theory, but as Hauser and Dröscher suggest, "should be conceived as a *phenomenological model* to explain the existence of the six fundamental forces." There is no experimental apparatus for generating gravity-like fields capable of clear and verifiable detection, yet should one arise then the potential impact to industry and society suddenly becomes manifest and of interest to designers of products, buildings and urban environments.

SPECULATION ON AN APPARATUS

If generation of a gravity-like field equivalent to earth's pull were to require the creation of an apparatus the size of a football field, then applications other than those for basic scientific or military research are likely to provide an insufficient incentive for funding. Alternatively, if a 1g gravity-like field could be generated by a mechanism the size of an ICE (internal combustion engine) then a great diversity of applications would become possible.

In the short version of their 2007 paper, "Advanced Propulsion Systems from Artificial Gravitational Fields"[4], Dröscher and Hauser discussed how they would reconfigure the apparatus employed by Martin Tajmar[5] as a "bench test" experiment employing a spinning superconductor ring, though with some key differences in configuration. This apparatus would have two advantages:

1. *It would allow a gravity-like field to be produced through rotation at a constant angular velocity.*
2. *The novel arrangement of components would produce a gravity-like field with a force parallel to its axis of rotation –optimal for providing thrust against earth's gravitational pull. This configuration should maximize an axially propulsive force capable of countering earth's pull.*

They predicted that the strength of the gravity-like field could be multiplied relatively easily resulting in a propulsive force equal to earth's gravitational pull and perhaps even 2, 3 or 4 times greater. In devising a bench test they believed that their redesign could serve as the basis for a field propulsion principle.

Over several of their papers Dröscher and Hauser have suggested that the design would consist of a superconducting solenoid coil providing an imaginary induction field in the z (up) direction over the rotating disk. It requires that the coil be a different material than the superconductor and that the z-component of the gravitophoton field acting upon a large mass would be responsible for the gravity-like field above the disk.

One of the more interesting aspects of this configuration is that it is predicted to generate a secondary azimuthal (circumferential) torque that acts to rotate the disk. Therefore it may be the case that little or no additional input of energy would be required to keep the angular velocity of the disk constant.

Minimum specifications to provide a gravity-like field equivalent to that of earth vary between their 2009 and 2010 papers, but their 2010 paper to the AIAA specifies that a 0.015 g field (1.5% g) could be produced using:

- A solenoid 0.2m in diameter
- 50 turns of the coil
- Supplied with about 10 amperes of current
- A rotational speed of the disk of 50 m/s (angular velocity of 105 radians/second)

From these numbers an experiment could be conducted to determine if a device capable of lifting itself from the surface of the earth is within current limits of the technology.

A more robust design configuration capable of generating sufficient lifting force for a space vehicle would need sufficient current to produce a much stronger acceleration field. In practice a larger disk and bigger coils would also be needed to lift such a mass. As suggested in their 2010 AIP study, the gravity engine's configuration would consistent of components with the following specifications:

- Total space vehicle mass: 1.5 x 10^5 kg (150 metric tons)
- Mass placed above the rotating disk of 3.15 x 10^3 kg (3.15 metric tons)
- Supercooled disk rotating at 200 m/s (meters per second)
- Supercooled solenoid coil 1 meter in diameter
- Coil 1 meter in diameter
- 2,500 turns of wire in the coil
- Cross sectional area of the coil about 2.5 x 10^{-2} m^2
- Supplied with 10 amperes of current
- Provides an acceleration field upward of 1.3 g
- Generates a force of 1.98 x 10^6N (Newtons) or about 2.02 x 10^5 kg (202 metric tons)

The mass placed above the rotating disk is particularly important. The greater the mass the stronger the field produced. In the above configuration an acceleration of 47.6 g is produced through the 3.15 metric ton mass in the form of thrust, countering the estimated 150 metric ton weight of the craft. High density material would be advantageous because any mass in this location would experience a proportional force. The authors also specified that the disk and coil materials should be different though complementary, and they give the example of Tajmar's use of aluminum and niobium Type 1 superconductors.

Dröscher and Hauser have conjectured that the resultant acceleration field for this configuration should extend uniformly up to a height three times the radius of the disk and at greater distances becomes dipolar, much like the N-S propagation of a magnetic field. Physicist Robert Forward of the Hughes Research Laboratory proposed such a dipole for gravity[6] in 1963 in the American Journal of Physics. Such a dipole would also qualitatively describe Tajmar's experimental results of both a repulsive and attractive gravitational field, dependent upon the direction of rotation of the superconducting ring.

The 1.98 x 10^6N force calculated for this robust implementation of EHT compares favorably to the 2.1 x 10^6 N thrust for the Space Shuttle Main Engines reported for the former Space Shuttle System[7] and would do so without chemical propellants. On earth it would be equivalent to a force capable of a lifting over 200 metric tons. Subtracting the weight of the device as proposed (almost 150 metric tons), the payload capacity would be just over 50 metric tons.

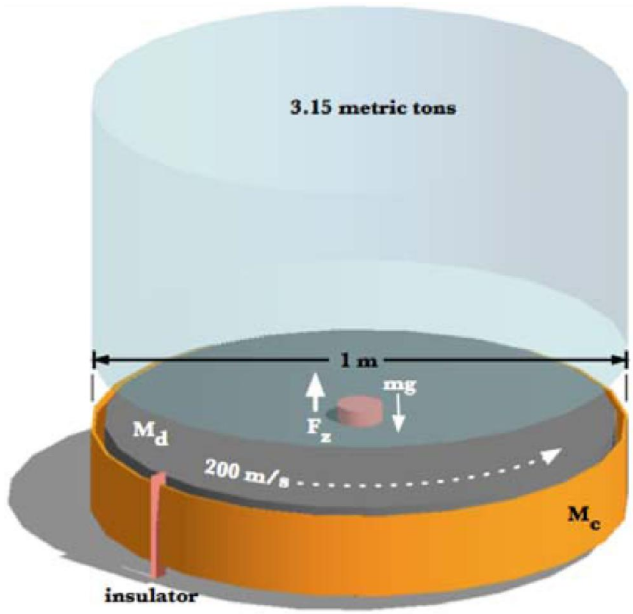

Figure 1 : A device consisting of rotating superconducting materials forecast to lift over 200 metric tons. G.Daigle; *Gravity 2.0*, Jet Flyer LLC, (2011).

What is 50 metric tons? Here are some comparisons:

- The approximate payload capacity of the Falcon Heavy Booster[8].
- The weight of a habitat that serves as both an IPV and Mars Surface Habitat[9].
- The amount of fuel burned during a transatlantic flight by a 777 carrying 300 passengers.
- The average weight of an adult male sperm whale –plus that of a blue whale (with a nod to Douglas Adams).
- The weight of tailpipe emissions of CO2 from a vehicle over ten years[10].
- The weight of a 1,000 square foot wood-framed home.

TERRESTRIAL APPLICATIONS

If methods of practical production are found to generate gravity-like fields, the remaining barriers to quick adoption of the technology would be primarily economic and environmental. They include:

1. *The technology must be competitively priced both to purchase and to operate in comparison to conventional technologies.*
2. *The technology must operate at an efficiency that allows it to perform work at various scales, ideally from palm-sized generators capable of lifting several kilos to room-sized generators capable of lifting hundreds of tons.*
3. *The operation must not present unacceptably high risks to operators, citizenry, or the environment.*
4. *Byproducts of production and usage must be managed and disposed of safely.*

Operational hazards for such generators are likely to include maintaining the superconducting temperatures, any biological effects due to proximity to electrical or magnetic fields and the dangers associated with projectiles produced from the failure of rapidly rotating rings. Then there are the risks of collisions or crashes as with any levitating vehicle plus the dangers inherent in full failures of propulsion and backup systems. Any negative environmental effects due to the mining, refining and recycling of the small amounts of materials employed in superconducting magnets are expected to be small but need to be included for a full environmental accounting. If any harmful byproducts are produced then their safe disposal will also need to be considered. Rapid adoption of "breakthrough" technologies have other hazards. They can accelerate the "creative destruction" of existing markets and of social patterns. The power of so-called "black swans" to produce a wave of change and supplant prior perspectives on the world is well known. Despite any absence of malice, the use of gravity-like field generators would likely displace some established industries. Joseph Schumpeter's previously mentioned theory of "creative destruction" offers that an essential part of capitalism is to have radical innovations supplant old ideas and break the back of virtual monopolies. As he states in his book Capitalism, Socialism and Democracy[11]:

"The opening up of new markets, foreign or domestic, and the organizational development from the craft shop and factory to such concerns as U.S. Steel illustrate the same process ... that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism. It is what capitalism consists in and what every capitalist concern has got to live in ... Every piece of business strategy acquires its true significance only against the background of that process and within the situation created by it. It must be seen in its role in the perennial gale of creative destruction; it cannot be understood irrespective of it or, in fact, on the hypothesis that there is a perennial lull..."

Applications in Low Earth Orbit

The first and perhaps most obvious outlet for generating gravity-like fields is for space travel. If the expensive and environmentally hazardous use of chemical propellants continues it may limit the number of spaceports and undercut a vibrant space-economy.

Propellantless propulsion methods such as gravity-like field generation would circumvent those limitations.

According to a draft report from the EPA's National Center for Environment Assessment[12] "One major source of contamination is the manufacture of ammonium perchlorate for use as the oxidizer component and primary ingredient in solid propellant for rockets, missiles, and fireworks."Perchlorate is a harmful thyroid toxin which can be found in contaminated ground water and drinking water in 28 states and territories in the US. In March 2009 an article in Nature[13] reported that 15 brands of powdered infant formula –all of the commercial brands tested –were contaminated with perchlorate and those containing bovine milk-based formula may have exceeded levels that the EPA considers safe.

Though space-tourist oriented spaceports have been established, an industrial spaceport remains just a dream –and a polluted one at that. A spaceport exclusively using gravity-like fields as a propulsion method would have fewer environmental concerns. That alone may change the economic equation. Perhaps every state may have as many spaceports as they have major airports. Spaceports might even become as common as regional airports.

TABLE 1 : Near Earth applications

Sector	Application	Usage	Outcome
Space applications	Surface to LEO	Raw materials	Iron
			Water
		Processed	Prefab structures
	LEO	Remove debris	No space junk
	Geosynchronous	Satellites	Communications
		Shields	Solar shading
	Tug services	Travel to LEO	Maintenance
			Orbital taxis
	Imports	Ores	Processing

An industrial spaceport should have the capability of receiving cargo and transferring it to all modes of earth-bound transportation. We currently have no prospects for trading partners in space, so what incoming cargo would this include? Perhaps the import of ores and the export of refined materials for colonization. Certainly, existing seaports and inland ports with high traffic would be good candidates since they already are the hubs for transportation networks employing highway, rail and seaways.

Some potential applications for industrial spaceports are listed in TABLE 1. One early application would be clearing orbital paths of space debris in Low Earth Orbit (LEO). Space junk is the debris remaining in orbit from launches, maneuvers, ejected shielding and includes bolts, insulation, etc. Domestically it is tracked by NASA's Orbital Debris Program Office (ODPO) where they predictively model its trajectory and behavior. Millions of pieces of debris[14] are traveling at orbital speeds faster than a rifle bullet. Currently the most effective means of limiting satellite collisions is to remove non-functional spacecraft and launch vehicle orbital stages from orbit.[15]

Once propellantless propulsion becomes tenable, the most direct means may be to simply "scoop"up the debris with the orbital equivalent of a Roomba. Cleared of debris, orbital pathways become available for higher levels of traffic for satellites and platforms. When positioning a satellite is not limited by the amount of propellant that can be lifted into orbit then any platform can become geostationary, making the crowding of geostationary communications satellites a non-issue and improving their performance since such platforms would be located a small fraction of their previous orbital distance. It also opens the possibility of satellites that would "chase"the sun delivering either shaded or additional reflected sunlight to a stable location on the earth throughout much of the day.

Industrial applications

In a 2006 New Scientist magazine[16] cover story, Martin Tajmar stated that, "Levitating cars, zero-g playgrounds, tractor beams to pull objects towards you, glass-less windows that use repulsive fields to prevent things passing through. Let your imagination run riot: a gravitomagnetic device that works by changing the acceleration and orientation of a superconductor would be the basis for a general-purpose force field." Tajmar also mentioned the potential of building zero-g simulators on earth.

A singular, propulsive generator would provide thrust along a single vector. Could two or more generators interact in ways to shape or focus a gravity-like field? The shaping of acoustic[17] and optical beams[18] has been shown to direct particles, even around corners. The shaping of gravity-like fields might produce gravitational equivalents of mechanical forces employed for industry for bending, shaping, shearing and punching holes.

Diffusing a gravity-like field could similarly be useful in applying either a repulsive or attractive force to control the distribution of gases, liquids or small particles. Repelling air molecules in a spherical pattern might suppress combustion within a zone through the creation of a localized partial vacuum. It may also be useful for generating "thrust" fields to act as window-like barriers. Creating a spherical attractive field could act as a membrane to contain inert gases for welding or restrain grains or liquids from shifting during transport.

TABLE 2 : Industrial applications

Sector	Application	Usage	Outcome
Industrial applications	Manufacturing	Fabrication	Shearing Bending Punching Shaping
	Shipping	Granular materials	Grains Gravels
	Vacuumization	Metals	Coatings
	Shielding	Processing plants Fabrication plants	Foods Clean surfaces
	Containing gases	Welding	TIG/MIG
	Glassless windows	Extreme environment	High temperature
	Foil bodies	Aerodynamics Hydrodynamics	Airfoil Hydrofoil

Zero-g industrial fabrication facilities initially planned for the International Space Station could be achieved at a fraction of the cost here on earth. The 2001 ESA report "A World without Gravity"[19] is an encompassing study on microgravity research that has occurred in orbit and includes a review of current and future explorations in space medicine, space biology, physical sciences and commercial spinoffs. This compendium of research on biological and physical systems while in orbit sheds light on the potential terrestrial applications derived from those very short duration studies of microgravity.

A key limitation to the continuation of microgravity studies is the limited access to microgravity conditions. Without greater access the opportunity for expanding the scope and duration of microgravity studies is very limited. Successful demonstrations of gravity-like field generation would render that limitation moot.

The biggest hindrance described in the ESA report are the commercial applications and technology transfer for spin-offs of the research conducted in orbital microgravity environments. Many of these innovations were for devices used during measurements or fabrication, while others have direct potential for non-microgravity earth-bound applications. These include car engine controls, measurement of liquid flows, holographic cameras, thermal insulation, thermoelectric coolers, and humidity management. All this just derived from studying microgravity for short periods of time in orbit. Imagine what could be discovered when such experiments are conducted on earth in thousands of laboratories for a mere fraction of the cost of a space mission.

Clean laboratory applications

Microgravity environments on earth could be employed to grow large defect-free silicon, germanium and even protein crystals in suitable zero-g clean-room laboratories. As the demand continues to grow for defect-free semiconductors and thin sheets of remarkable new materials like graphene, microgravity facilities may become the new standard in environments for growing microelectronic substrates.

TABLE 3 : Laboratory applications

Sector	Application	Usage	Outcome
Laboratory	Growing crystals	Silicon crystals Proteins	Computer chips Prescription drugs
	Zone refining	Immiscible alloys	New metal alloys
	Centrifuging	Gaseous separation Isotope separation	CO2 separation Isotope markers
	Gravity lensing	Gravito-optics	Telescopes

Low microgravity conditions could also be employed to create new metal alloys not easily melted together due to differences in the specific gravities of the constituent metals. In zero-g molten materials of different specific gravities mix more readily. Foam steel (like foam rubber), iron-lead alloys with unusual electronic properties, composite materials –all can be made more reliably in near zero-g conditions.

Medical applications

Medical applications for gravity-like fields are also varied. Using local gravity-like fields to counter the earth's natural gravitational field to a fraction of its normal strength would lessen the weight (but not the mass) of the human body. That capability would be useful for reducing pressure on the skin.

Lessening such constant pressure would help prevent bed sores and aid in the healing of severe burns. Bed sores can lead to life-threatening conditions for quadriplegics, such as the condition that led to the death of actor Christopher Reeves. Reducing the full weight of the body on second and third degree burns not only alleviates pain but also speeds healing and reduces breaks in the skin, which are potential sites of infection.

In space studies NASA scientists have established that long periods of weightlessness produces medical complications. Astronauts are known to experience muscle atrophy[20] while in weightless conditions and cells produce more proteins that negatively regulate bone density[21]. In addition, the weakening of the body's immune system and its resultant lowered ability to fight off infection provides a challenge for long-duration space flights. The use of gravity-like fields to induce an artificial gravity for space flight would help astronauts maintain their health during lengthy transits such as proposed missions to Mars taking seven months.

Construction, mining and safety applications

The construction industry could benefit in several ways. Platforms with propulsion fields could hoist materials and rather than install thousands of square yards of plastic sheeting to protect workers from rain and cold weather, a wide-beamed field of sufficient size could keep workers dry and protect them from wind. Standing fields aimed skyward could act as "repulsive safety nets"to break falls from buildings, bridges and other structures.

Fields could provide temporary support of earthen walls while digging foundations, wells or trenches. Lower intensity standing fields could also protect miners by providing fire "check curtains" and mobile safety areas prevent the spread of carbon monoxide, moving with the miners as they make their way toward exits. Repulsive gravity-like fields could be employed in products to extinguish fires by expelling air. Stronger fields installed in staircases could generate repulsive thrust fields to reduce the danger of falls by the elderly or those with physical disabilities.

Consumer and sporting markets

Second and third generations of material and digital technologies frequently find their way to consumer secondary markets. Once initial tooling for production is amortized the cost of production lowers to where it can also find its way to consumers in the form of graphite tennis rackets, sensors for running shoes and other applications. These next generations of gravity-like field applications will introduce the technology into consumer markets fomenting a wider adaption of the technology into society.

Assuming that field-sized versions of weightlessness can be developed through gravity-like fields then space sports[22] on earth will quickly follow. The Zero Gravity Corporation[23] already offers parabolic low altitude flights where you can play dodge ball, tag and paraball (parabolic football) for short periods of time in zero-g. The price for half an hour of parabolic weightlessness is just 2.5% of the $200,000 price of a ticket for Virgin Galactic's suborbital flights.

Security and defense

In Chicago there are an estimated 10,000 surveillance cameras[24] both private and public. A 2002 working

TABLE 4 : Medical applications

Industry	Application	Usage	Outcome
Medicine	Hypergravity	Therapy	Osteo therapy
		Conditional	Sports Rehabilitation
	Microgravity	Skin treatments	Burns Bed sores
		Circulatory	Reduce pooling
		Respiratory	Fluid removal
	Variable environment	Conditioning	Space travel

TABLE 5 : Construction, mining and safety/rescue applications

Sector	Application	Usage	Outcome
Construction and Mining	Hoisting	Beams/sheets	Building construction
		Bulk materials	Bridge repair
	Excavation	Trenching	Wall supports
		Mining	Tunnel supports
	Flood	Flood abatement	Damming/dikes
Safety and Rescue	Rescue/recovery	Collapsed building	Victim removal
		Skyscraper fire	Evacuation
		Ice or water	Extraction

paper by UrbanEye[25] estimated that the number of stationary surveillance cameras in private premises in London is around 500,000 and the total number of cameras in the UK is around 4,200,000. Low-payload gravity-like field platforms might easily be outfitted as camera platforms that can be positioned in any location and at any elevation to fill in the gaps in stationary surveillance.

TABLE 6 : Sporting applications

Sector	Application	Usage	Outcome
Sports	Flying sports	Equipment	Quidditch
		Arena	Paraball
			Real "Asteroids"

TABLE 7 : Security/Privacy applications

Sector	Application	Usage	Outcome
Security/Privacy	Platforms	Advertising	Smart billboards
		Surveillance	Class G cameras
			"Tinkerbots"

Amazon recently made headlines by demonstrating limited drone schemes for drone delivery. There is already a generation of flight-capable devices such as mini-drones[26] able to place electronic eyes just about anywhere. With the use of gravity-like field camera platforms the occupants of high rises would no longer be able to consider their residences as private and secure from prying eyes. Window coverings for every window would be needed for privacy, as would locked and armed balcony doors in high rises, as if on the ground floor.

With the invasion of privacy would come an increased ability to protect, such as with the drone[27] built by a father to follow his son to school. A new class of silent "tinkerbots"to protect and monitor child safety are possible.

TABLE 8 : Defense applications

Industry	Application	Usage	Outcome
Dystopic Uses	Terrorism	Public venues	Crumple bombs
	Criminal intent	Theft	Fence jumping
	Limiting civil rights	Crowd control	Suppression zones
		Surveillance	Big brother
	Zealotry	Fulfilling prophesy	Relocating shrines
	Unfair business	Industry destruction	Monopoly
		Harmful byproducts	Pollution
		Unappealing uses	Sex trade

Defense applications similarly will be controversial. The use for non-lethal weaponry and to protect soldiers'lives will likely drive usage. Unconventional applications could potentially benefit the military. Hyper-gravity devices developing short intense bursts of attractive gravitational fields could be used in a "crumple effect" pulling structures in on themselves. While the end result of demolition would be nearly the same as bombing structures, it would minimize collateral injuries produced by debris ejected during explosions.

As with any technology, the potential for misuse or abuse exists. Physical conflicts between protesters and law enforcement have led to new technologies for dispersing mobs and groups of protesters. Microwave pain-generating beams for ground-based[28] and air-based[29] active denial systems (ADS)[30] employed for crowd control have been marketed for civilian use.

TABLE 9 : Dystopic applications

Sector	Application	Usage	Outcome
Defense	War zones	Detention	Suppression fields
		Surveillance/reconnaissance	Gravity drones
		Post-combat	Clearing land mines

Gravity technologies could be used by law enforcement to control crowds, detain illegal protesters and impede illegal dissent. It is plausible that gravity technology for generating local hyper-gravity zones of two or three "g's"could be used to restrain or slow the advancement of protesters by making them too heavy to move quickly.

Transportation

In the 1982 science fiction film "BladeRunner" futurist Syd Mead envisioned a dark and dystopic vision of the year 2019. That future is as far removed from a fun-filled outing visualized by Mead in his 1961 book "Concepts" for U.S. Steel as one could imagine. In Blade Runner, flying (not just hovering) vehicles known as "spinners"[31] are reserved for police business. They are a symbol of authoritarian power as they drop down from the sky while common citizens ride in public taxis that look like a cross between an aging Zamboni and a holding cell.

The propulsive uses of gravity-like fields will make possible a new category of flying vehicle that does not fit neatly into any current statutes for aviation. There are three common types of flying vehicles recognized by the Federal Aviation Administration (FAA) of the U.S. government. Hovercraft, fixed wing aircraft and rotorcraft describe most types of recognized non-sport aviation, though none describe a propellantless propulsion craft.

Pilotless craft may arrive before piloted craft meet governmental approval. Already Amazon has experimented with delivery drones because they view the economic model is valid. Delivery of physical goods

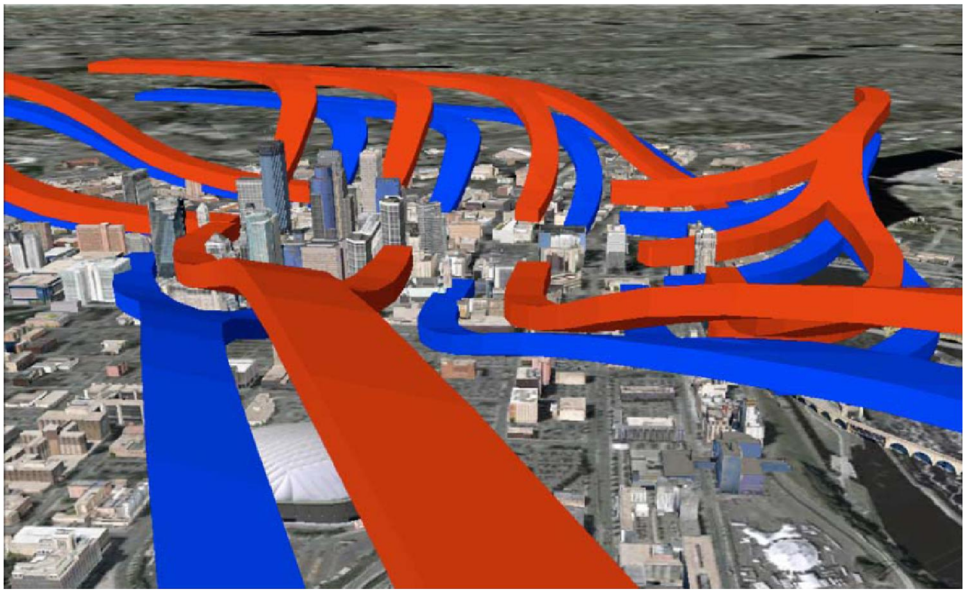

Figure 2 : Downtown commuter flyways depicting spatial corridors: blue for ingress and red for egress. G.Daigle; *Gravity 2.0*, Jet Flyer LLC, (2011).

could mimic the delivery of packetized data of the Transmission Control Protocol (TCP) employed by the Internet. Individual packetized shipments shipped via autonomous platforms would travel trunk corridors to their destinations and forego distribution centers. As routing to more refined destinations is needed, shipments could split into individual "mother platforms" each with its own set of "daughter platforms" capable of delivery to specific destinations.

Such vehicles would require safe flying spaces at close quarters with "Vehicle-to-Vehicle,"or "V2V," communications, a key component of the connected vehicle research program within the Intelligent Transportation Systems Joint Program Office of the U.S. Department of Transportation (USDOT) Research and Innovative Technology Administration (RITA)[32]. Recent advances in collision avoidance and lane assist employed for autonomous vehicle research can also aid the development of safe protocols for vehicles moving in 3D spaces.

Applications for architecture

The range of architectural possibilities are described by the term "gravitecture+", borrowed from the work of Professor Shuhei Endo of Kobe University. The original meaning of gravitecture[33] being "architecture that goes gracefully with gravity." That seems appropriate for this new technological capability, with the "+" indicating the addition of gravity-like fields to go gracefully with architecture. In this context it is used to denote implementations using gravity design to either augment or completely float structures.

TABLE 10 : Transportation applications

Sector	Application	Usage	Outcome
Transportation	Gravity-assisted	Load reduction	Suspension
		Friction reduction	Drivetrains
			Bearings
	Flying	Private	Commuter
			Recreation
		Fleet	Multi-passenger
			Heavy utility
	Routes	Urban flyways	Commuter traffic
		Delivery flyways	Goods shipped
	Smart networks (ITS)	Safety	Piloted vehicles
		Efficiency	Autonomous drones
	Building accommodation	Commuter vehicles	Parking
		Workspace	Vehicle as work pod

TABLE 11 : Architecture applications

Sector	Application	Usage	Outcome
Architecture	Gravity-assisted	Cantilever structures	Balconies Overlooks
		Load reduction	Preservation
		Reinforcement	Earthquake proofing Hurricane and tornado
		Stabilization	Flood waters, tidal surges, tidal waves
	Floating	Legal rights	Right to Light Right to View (air rights) Roaming Rights
		Structures	Residential Barges Factories

Cantilevered buildings[34] are commonly designed today with existing materials and technologies but require a disproportionately large engineering effort to making them both possible and safe. For example, the cantilever bridge of the Guthrie Theater in Minneapolis, completed in 2006, is 178 feet long and 30 feet wide making it one of the longest occupied cantilever structures ever. It is the equivalent of a 12 story building sticking out of the side. This "Endless Bridge"as it is known has a 1,650 ton load requiring that it be anchored by two 1,375 ton concrete ballasts.

With gravity-assisted architecture remarkable arches and spans –not gravity-defying but gravity-field employing –would be possible. The Googie or Populuxe movements exemplified by the Space Needle in Seattle and the Los Angels International Airport's Encounter Restaurant and Theme Building come to mind. Gravitecture+ would make possible even more remarkable spans and arches. Augmenting the engineering with thrust, traction or standing fields would allow previously unstable designs to become stable –assuming that the power source making possible the augmentation is uninterruptible. Possibilities include:

- Arches with much wider clear spans that would otherwise be possible for a proper rise (arch height) or without sufficient abutment (countering bowing forces).
- Larger or more massive balconies and cantilevers or cantilevers with less massive counterbalances.
- Taller and more elongated towers and skyscrapers.

The incentives to design untethered (or unmoored) floating buildings are many. They include the benefits of no associated land costs, an unobstructed view (at least until neighboring buildings are floated), flexibility in site selecting and the ability to easily relocate. Homes without "affixation" to the ground have precedence in mobile motor coaches, considered personal property rather than real property. Real property establishes the basis for a property tax and the assess-

Figure 3 : Visual sketch of floating homes and flyways. Jet Flyer LLC (2014).

ment of fees and rates for basic services. If a gravitecture+ residence were impermanent then its payment for basic services (power, water, etc.) could be assessed anywhere that the structure comes to rest, whether it be on the owner's property or some type of leased or rented mooring station.

Are there exceptions to the affixation standard for residences? Yes. Take the case of float homes on Lake Union in Seattle such as the one featured in the film "Sleepless in Seattle." They are a type of houseboat that is floating architecture[35]. If some residences that float on water can be classified as real property then what if the medium were not water but air?

Whereas the passing shadow of a fixed wing aircraft, helicopter or even a blimp may last from a split second to a few seconds, a building structure may cast its shadow for hours, days, even years. The only motion of the shadow might be from the changing position of the sun. In addition, gravitecture+ would cast a shadow larger than a land-based building of the same size for the simple reason that a building on the ground already sits on part of its shadow.

Gravitecture+ is more than just a floating building. It is also a complex mix of municipal interests and responsibilities to support such a capability. These include:

- Navigational beacons and automated traffic control systems
- Engineered quick release mooring hookups for temporary supply of fuel, water and sewer
- Extensions of building and inspection codes
- Property rights easements for blocking sunlight, view, rainfall
- Roaming agreements for transience
- Property tax assessments
- Revised assessments of services
- Licensing for operation within Class G airspace
- Coordination with overlapping regional systems for aviation and transportation
- Coordination with plans for future regional growth
- Uninterruptible mobile power systems and redundant backup systems

Powering mobile architectures

A Distributed Energy Resource (DER) and backup system with high power density and continuous operation would be a necessary requirement for floating architecture. A power source with a high power to weight ratio and a high specific energy is most desired. Energy storage devices such as lithium ion batteries used in laptop computers and in electric vehicles such as the Tesla roadster, are generally rated with less specific energy than methanol or gasoline fuels, making it an important consideration for electric-powered aircraft. Promising technologies such as super capacitors and super flywheels have a higher peak power density but less energy per kg. Nuclear power has a much higher specific energy than chemical fuels, but the likely social reaction to the prospect of adopting a system employing tens of thousands of flying nuclear reactors is remote.

LENR (Low Energy Nuclear Reactions) was mentioned in the book Gravity 2.0[36] as a controversial yet promising candidate for powering mobile gravity-like field generators. Early research by Celani[37], Piantelli[38], Mizuno[39] as well as demonstrations in early 2011 by professors Andrea Rossi and Sergio Focardi of the University of Bologna were seen at the time as promising technologies.

Rossi's E-Cat was the subject of a 2013 independent study conducted by a team of researchers from Bologna University (Italy) and Uppsala University (Sweden), reporting that Rossi's latest iteration of his reactor produces anomalous heat, "*that is one order of magnitude higher than any conventional source.*"[40] That is, with the most conservative of figures and assumptions, the heat produced is at least ten times higher than that of any chemically energetic reaction known. Its energy density was measured at 4 orders of magnitude greater than gasoline and 2 orders of magnitude less than Plutonium-238. Power density was rated at 3 orders of magnitude greater than Plutonium-238[41]. A Ragone plot of energy density is reproduced in Figure 4.

In November 2013, The Swedish energy research institute Elforsk[42] published a report providing an overview of the history and current state of research in the field of LENR. As stated in the Elforsk Report, there are several companies planning to commercialize products based upon LENR technology including Defkalion Green Technologies and Brillouin.

The online research clearing house LENR-CANR[43] has accumulated over a thousand original research papers on LENR and related energy research papers that have their beginnings in the "cold fusion"studies of Pons and Fleischmann. Recent advancements in the field covered by online websites such as E-Cat World[44] include Nanor devices developed by Mitchell Swartz and Peter Hagelstein of MIT[45]. Confirmation of the production of excess heat has also been reported by Michael McKubre, former director of the Energy Research Center at SRI International. Of over a dozen devices tested by McKubre's team, five claims of excess energy production were confirmed. McKubre further clarified that the source of the excess heat by

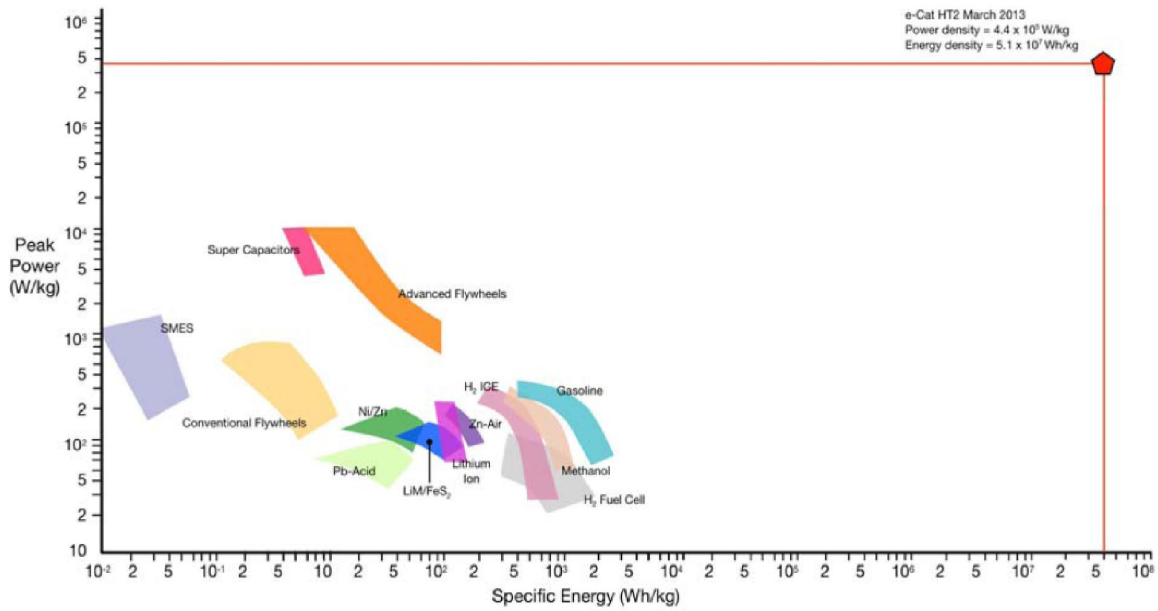

Figure 4 : Ragone plot of the energy density and power density of various sources as compared to the E-Cat HTs (aka "hot cat"). Ragone plot of the energy density and power density of various sources. Derived from Forbes by Alan Fletcher based on the original figure by Ahmed F. Ghoniem. "Needs, resources and climate change: clean and efficient conversion technologies," Progress in Energy and Combustion Science 37 (2011), 15-51, fig. 38

his statement that it is a "nuclear fusion process."[46] In January of this year, the Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) announced a funding opportunity for several areas of research including low-energy nuclear reaction (LENR) research[47].

Pubic policy impacts

Should a substantial population take advantage of the wonder-lust possible with floating architecture, real-time methods of collecting GIS (Geographic Information System)[48] data for mapping and measuring dynamic populations in motion and over time would be required to track population drifts. The MIT SENSEable City Laboratory[49] employs automatic data acquisition through mobile devices to study and predict the changes that cities undergo as interconnected computational elements become available almost everywhere. Realtime data acquisition though such tools may become models for tracking dynamic changes in demographics. Being able to track and "load balance"delivery of public services, just at IT managers load balance Web servers for busy commerce sites could become a major function for city and regional CIOs.

With residency comes both the burden of taxation and the opportunities for representation. Boats and houseboats are not taxed for property improvements since, as with motor homes, they are not affixed to property and are often in a state of transience. However moorages and slip fees are associated with property taxes. Based upon local regulations, float homes occasionally incur an additional "shadow tax" where, as in California's tony upscale town of Sausalito, land properties underneath the floating home are considered improved by the adumbration (i.e. vague shadow or outline) that the floating home casts upon the bottom of the bay. This shadow tax may have implications for collecting taxes on gravitecture+ residences. Or perhaps, like the sharing of carriage fees across cellular networks, a "roaming" tax for local governments to assess property taxes through sharing agreements with other local governments.

TABLE 12 : Public policy impacts

Industry	Application	Usage	Outcome
Public Policy	Regulatory changes	Federal	Commerce
		State	Transportation Safety
		Municipal	Gravity zoned
	Citizenship	Residency	Roaming rights
		Demographics	Z-axis GIS

Residential elevation has always been directly associated with social status and, more recently, economic status. Another name for it is "vertical classism". Dystopias in fictional literature and film frequently depict the privileged living in towers above the city, sometimes even above the clouds.

Residents of floating cities and islands in fiction are portrayed as rich and privileged (Jonathan Swift's Laputa being a notable exception) living far above the

TABLE 13 : Social impacts

Industry	Application	Usage	Outcome
Social Impacts	Economic divides	Housing	Vertical divide
		Transportation	Roadway vs flyway

TABLE 14 : Sematic impacts

Industry	Application	Usage	Outcome
Semantics	Common usages	Vocabulary	gravity terminology
		New meanings	"uplifted" by gravity

common concerns of those living at lower elevations. In the era of vast agricultural estates land owners watched over the field workers from the "main house"where they could survey their lands. In the early industrial age owners looked down from estates on hillside summits upon the workers arriving at their factories and mills. Such residences were a symbol of power and economic privilege. Mansions "on the hill"occupy our great literature from Citizen Kane's Zanadu to Jane Eyre's Thornfield Manor. Gravity technology merely offers a means to exercise this classism to a degree never before realized by even the loftiest of mansion dwellers.

New connotations of language

In the English language gravity is a synonym for weightiness, importance, seriousness, severity, concern, consequence, hazardousness, perilousness, significance, urgency, graveness, gravitas, soberness, solemnity and somberness. Its antonyms include levity, buoyancy, flightiness, frivolity, silliness, unimportance, inconsequentiality and light-heartedness.

Gravity is age-biased. It is the rare individual over 60 who feels "light on their feet" any more. In our youth we are bouncy, "feeling up", reaching for the sky –all terms requiring the common experience of gravity as a counterpoint. Athletes in their youthful prime "fly around a track", "float like butterflies" and "catch air" on a BMX bike. New graduates hold "high aspirations", are ready to "fly to new heights", conquer Everest, and "take wing". However, in old age it pulls on us and it's all we can do to resist. Gravity literally makes us shorter with age (by compressing our vertebrae), eventually and irreversibly pulling us to our grave (employing the same Latin root as gravity).

With gravity modification, verbal associations with all things vertical would have to be reconsidered. People with economic trouble are said to be "down on their luck" or having "fallen on hard times". Pragmatists are steadied by having their "feet on the ground". Social climbers have "lofty ambitions". The socially privileged are referred to as living the "high life", being part of "high society" or being ensconced in the upper class or upper crust, while elitists are thought to consider themselves as "high and mighty".

A new gravity modification meme deriving from the idea that gravity is variable, pliable, even reversible would likely be accompanied by a significant semantic change in the connotations of the word "gravity."

As with the origins of the terms "perspective" and "relativity", new contexts can impart new meanings and generate a new "strain"of verbal meme with the potential to sweep the public zeitgeist. After gravity design achieves some critical level of public awareness the meanings imparted by the word "gravity"will likely change in a world where gravity is optional.

CONCLUSION

In the book *Gravity 2.0*, this author described a preference for using the term *gravity modification* to describe the net effect of the interaction of gravity-like fields and natural gravitation. To distinguish use of gravity modification in this context, the term "gMOD"(shorthand for *gravity modification*) was selected to describe the purposeful application of generating gravity-like fields as part of a proposed discipline of "gravity design".

The prefix "g" borrows from other distinctive and disruptive technologies made possible through a focus upon design, such as Apple's usage of the lower case "i" preceding its line of mobile products iPad, iPhone, iPod, iMac, and iSight despite their minor crime against grammar[50]. ConsidergMOD as the root for a proposed category of "g-devices" employing the effects of "gravity modification".

The opportunities for expressing new designs in architecture, transportation, consumer goods and industrial applications are yet to be realized, but the design community is ready for the challenge.

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