The Water Bullet:
Small-Diameter Vacuum-Enhanced Magnetic Levitation for Material Transport

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Executive Summary

While magnetic levitation (MagLev) systems have been well established for human transport, the concept of material transport using similar technology has been under-investigated. Establishing a Small-Diameter Vacuum-Enhanced MagLev (SDVEML) system would allow for virtually limitless transportation of materials, at significantly lower costs. SDVEML applications include mass transportation of aggregate, grains, and, perhaps most significantly, fresh water. SDVEML has the potential to distribute readily available, but currently untransportable, resources in a nearly unlimited fashion.

Summary of Existing Technologies

Gerard O'Neill pioneered the concept of Magnetic Flight in the 1970's. MagLev trains were already producing speeds in excess of 150 m/s, with the main speed limitations being air resistance and centrifugal forces. O'Neill and others proposed that if a MagLev train was placed in a vacuum chamber, air resistance would be negligible, and that if the line were built underground, alignment could be precise enough to avoid excessive centrifugal forces (Figure One). O'Neill's vision was to travel "from New York to Orlando in half an hour… [using] less energy than… a liter of gasoline". Despite the enormous capital costs of establishing such a VacMagLev system, O'Neill saw its construction as being only a matter of time.

Subsequent patents have refined the details and potential applications of a VacMagLev system. Over 250 patents have been issued refining MagLev technology. Proceedings of the International Conference on Magnetically Levitated Systems and Linear Drives expand on innovations in the field, with occasional focus on smaller, freight based systems, in particular, O.J. Fiske's low cost Magtube (Figure 2):

http://www.maglev2006.de/152_Fiske_1/152_Fiske_ok.pdf

In fact, this report offers no new advances in the mechanics of the technology. What this proposal offers is a re-visioning of the practical benefits of such technology.

Conversion of Proposed Technology to Material Transport

VacMagLev systems have been postulated based on the dubious presumption that humans need to get places faster. While the idea is a noble one, small-diameter equivalent systems for freight actualize a higher ideal: any material can be transported, in vast quantities, with minimal energy input.

Limitations of Material Transport

I have worked primarily in two fields in my career; the manufacturing of aggregates (sand, crushed stone, and gravel), and the distribution of potable water. Both fields are similar, in the sense that transport costs are by far the limiting factor. In the aggregate industry, aggregates are often transported hundreds of miles by truck. Because of high transport costs, aggregate mining tends to be chiefly a local operation (every one of Oklahoma's 77 counties reports at least one mining facility). In areas where limestone is scarce, the cost of aggregate, thus concrete, thus construction in general, skyrockets.

Similarly, potable water transport is limited. Pipeline friction forces prohibit velocities exceeding 3 m/s. Due to this speed limitation, large quantities of water demand enormous pipe sizes.

By contrast, in a SDVEML system, transport is not limited by velocity. Since friction forces are negligible, the only pumping costs are associated with raising water or aggregate to a higher end elevation. If the end elevation is lower than the source elevation, energy can actually be created through regenerative braking.

Case Study: Lake Superior – Colorado – New Orleans (Figure 3)

For the purposes of this study, a 1-meter SDVEML system is modeled, with a maximum velocity of 2000 MPH (900 m/s).

Each of the areas in this trade triangle has valuable resources as well as desperate needs.

Water:

Scarcity:

Within a 50-mile radius of Western Colorado sit the sources of the Colorado, Arkansas, Rio Grande, Platte, and Canadian River Watersheds. Notable among these watersheds is the main recharge area for the Ogallala Aquifer, which covers eight states (Figure 4). Several years of persistent drought have caused a water crisis in the Western States.

Abundance:

Lake Superior has a fresh water capacity of 12,000 cubic kilometers (3000 trillion gallons). Each inch of depth equates to 559 billion gallons of water. The Great Lakes discharge 235 billion gallons per day of fresh water through the St. Lawrence Seaway, never to be recovered.

Rock / Elevation:

Scarcity:

New Orleans is in desperate need of improved levies. Limitations on material transport have historically resulted in inadequate designs. However, if materials were essentially unlimited, levies and artificial islands (similar to the Palm Islands of Dubai – Figure 5) of indefinite size can be constructed.

Abundance:

Saguache County, Colorado is sparsely populated, sits on the continental divide, and has elevations in the range of 9,000 to 13,000 feet.

Oil & Gas / Misc. Materials

Scarcity:

While the Great Lakes area is well serviced with pipelines, roads, and rail systems, SDVEML could take some demand off of such systems, at substantial energy savings.

Abundance:

New Orleans serves as a hub of the petroleum industry, as well as a connecting point for goods transported by sea.

Aggregates from Colorado would be shipped to New Orleans for island building. Oil & gas as well as miscellaneous materials would be shipped from New Orleans to Lake Superior for distribution throughout the Midwest and Great Lakes shipping regions. Fresh water would be shipped from Lake Superior to Colorado to replenish the western watersheds and aquifers, and the cycle would re-commence. Since the aggregates flowing downstream are more dense than the water flowing upstream, energy is created.

The proposed network would supply aggregates for the creation of 157,000 acres of new land per year, provide 6.1 trillion gallons of fresh water to the western watersheds and aquifers, and create 12.7 GW of electricity.

Using very conservative assumptions, a Superior-Colorado-New Orleans triangle would generate over **$13 billion** in annual revenue, irrigate a large part of the Southwest, establish valuable oceanfront property, and protect coastal cities from flooding.

Other potential applications

Other applications could include:

- Replenishing of Lake Havesu & the Los Angeles Aqueduct (through the Colorado Hub)
- Alternative to Lake Superior, a water supply connection from Lake Ontario, which discharges 10,000 cubic meters per second (well in excess of the demands of this network). Note, however, that the water quality at Lake Superior is preferable.
- An exchange between salt water from the San Francisco area to the Nevada Great Basin, creating artificial islands on the Pacific Coast and a New Great Salt Lake in Nevada.
- A nationwide network, using the Colorado triangle as a hub, allowing for transport of grain, lumber, coal, iron ore, etc.
- Eventually, a global network allowing for unlimited transport of nearly any material to any point on Earth (Figure 6).

Financing

A capital works project of this scope requires enormous upfront investment. A cooperation of government and private funds is essential. The theoretical technology is well established, but no small-scale pilot programs have been established. Once those pilot programs are built and a real-world demonstration can be made, requests for investment will be more feasible.

Implementation Plan

Steps to take for implementation of the SDVEML are as follows:

- Prepare a feasibility study and economic analysis, consulting experts in the field of
    - Maglev systems
    - Regenerative braking
    - Pipeline engineering
    - Water law
    - Transport logistics
    - Mining
    - Artificial Island Construction
    - Electrical generation and distribution
- Based on the results of the feasibility plan, implement a series of pilot tests in cooperation with a major university. Potential projects include:
    - Benchscale model: a 20-meter diameter loop, maintaining a velocity of 10 m/s (centripetal forces = 1g), to determine long-term stability.
    - Field model: a 200-meter loop, maintaining a velocity of 50 m/s (3g).
    - A 4-inch diameter, 5 mile SDVEML pipeline (max. velocity = 100 m/sec) connecting Lake Thunderbird, Oklahoma, to the Norman Water Treatment Plant.
    - A 4-inch diameter, 100 mile SDVEML pipeline (max. velocity = 500 m/s) from Lake Atoka to Lake Stanley Draper, both in Oklahoma. Atoka is a major water source for Oklahoma City and is currently serviced with a 42-inch pipeline. This project would provide double the capacity with significant energy savings.
- Continue up-scaling projects, as funding allows. Seek private and government funding continuously through the process.
- Pending funding, perform an Environmental Impact Study (EIS) of the proposed full-scale plan. Note that an EIS for a project of this scope itself will cost several million dollars.

Additional Information

Additional considerations are included at the project website:

http://members.cox.net/waterbullet

Topics to be evaluated in the feasibility study include the following:

Political –
- Great Lakes conservation
- General environmental impacts
- Mountain destruction through massive mining
- Compare vs. doing nothing.
- Political feasibility
- Economic impact

Technical –
- Review of existing technology
- Seismic concerns
- Acceptable centripetal forces
- Safely acceptable acceleration and deceleration rates
- Regenerative braking
- Microtunneling
- Vacuum pumping
- Losses due to evaporation
- Loading & unloading procedures
- Drawing of unloading facility

Logistical -
- Potential routes & critical paths
- Hypothetical nationwide network
- Hypothetical global network

Climate Change
- Seaflow diverted to evaporation and percolation
- Ocean level impacts

Island Building
- Review of current technology (Dubai)
- Proposed dike & island dimensions
- Economic impact (ref: Bay Area & Miami land costs)
- Reef building / sedimentation effects

Emergency Preparedness
- Crash implications
- Vacuum pump failure
- Downtime implications