MAGLEV PIPELINE TO IMPROVE GRAIN SHIPMENTS FROM AMERICA TO ASIA

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SUMMARY

Magnetic levitation (Maglev) technology has been advanced to a level where several versions, and combinations thereof, can be considered 'proven technology'. For instance, in Disneyland, an amusement park owned by Walt Disney World Inc. in California, U.S.A., a system, called the PeopleMover, has been in operation since 1975. (ref. 1) . While the PeopleMover's linear induction motors (LIMs) operate at low speed, faster LIMs were designed (ref. 2), built and successfully tested (ref. 3) in the late 1970s at the Transportation Test Center near Pueblo, Colorado, U.S.A. This technology has now also been adapted for use to levitate and propel grain containers over long distances, such as from grain producing areas of the U.S.A.to the West Coast, at high speed and low cost, for subsequent shipment by large bulk grain carriers to Asia. Capacity requirements, logistics and financial feasibility of such a project was analyzed.

INTRODUCTION

The Present Trade Routes of American Grain to Asia

According to the US Department of Agriculture (USDA) roughly 50 million tons of grain are exported from America to Asia annually, of which about 17 million tons are transported by rail, at a rate of several unit trains/day, along the Canadian border from grain producing areas to the West Coast of the U.S.A. for shipment to Asia out of Portland, Oregon. (A unit train along this route consists of about 100 hopper cars, each carrying 100 tons of grain.) The other 33 million tons are mostly carried in barges down the Mississippi river to New Orleans, where they are reloaded into ocean going ships, which then have a much longer route to Asia than ships out of Portland. Bulk carrier sizes in present North America to Asia trade are limited by river channels, locks and canals to about 50,000 tons. Figure 1 shows a map of the Pacific rim area with present and proposed routes.

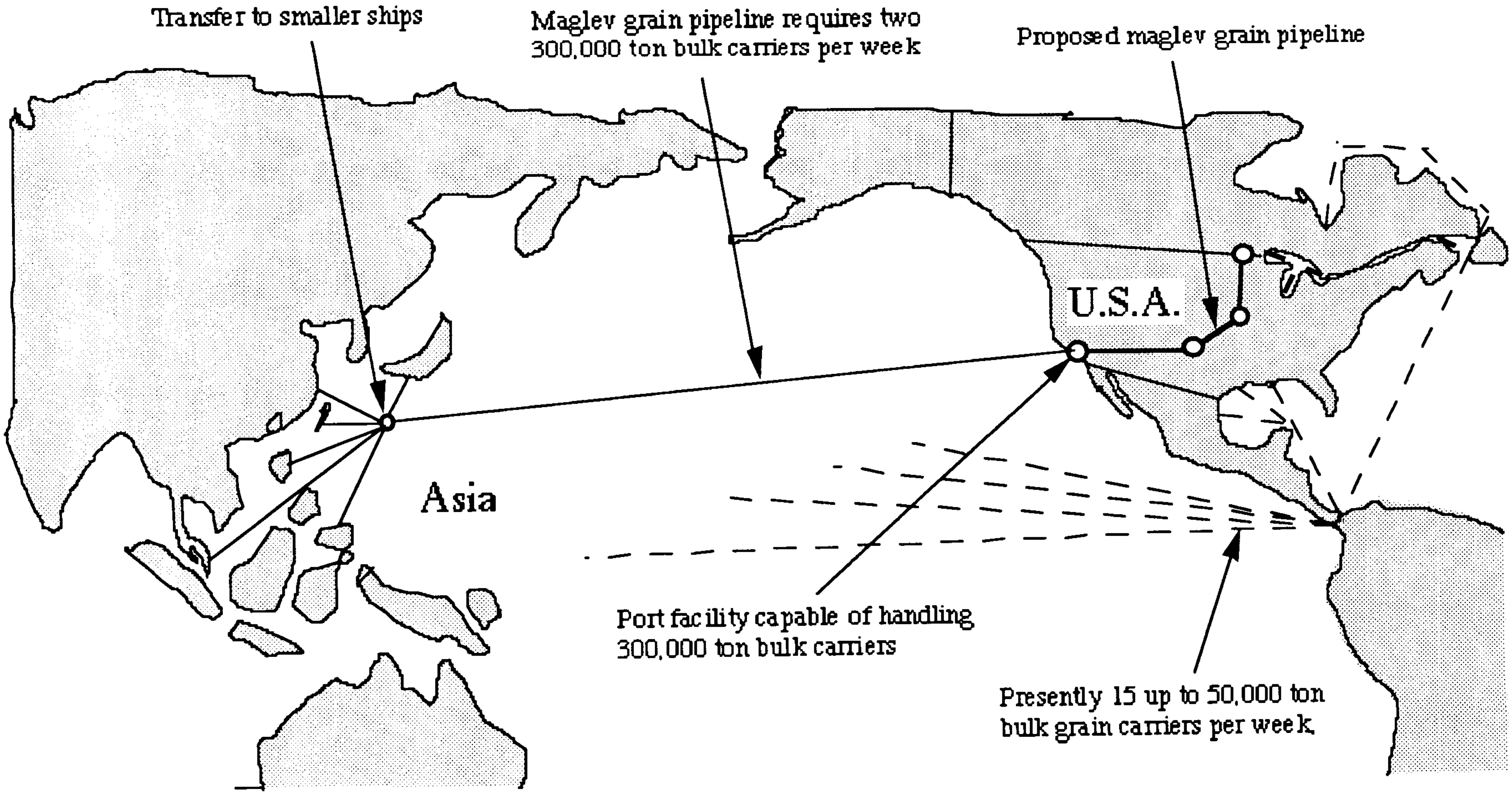

Figure 1. America to Asia route map

Costs of Shipping to Asia via Mississippi River

The cost (ref. 4), via the Mississippi River, imbedded in a ship load of 50,000 tones of grain arriving in Asia, breaks down to approximately $6 million for grain producing farmers, $6 million for transportation and storage from farmers' fields to on-board ship in New Orleans, and $2 million for the ocean voyage to Asia, for a total of $14 million. Factors in these costs include: Long-haul trucks 10¢/ton-mile (6¢/ton-Km), storage $1.00/ton-month, Mississippi barges 2¢/ton-mile (1.2¢/ton-Km), short-haul railroads 5¢/ton-mile (3¢/ton-Km), empty ship waiting for loading in New Orleans $4,000/day, loaded ship waiting to get through Panama Canal $8,000/day and Panama Canal fee $200,000 for passages back and forth.

Costs of Shipping to Asia via Railroad to California

The cost, via railroad to California, imbedded in a 50,000 ton ship load of grain arriving in Asia, breaks down to approximately $6 million for grain producing farmers (as above), $5 million for transportation and storage from farmers' fields to railroad loading docks in Topeka, Kansas, $2 million for the rail trip to California and $1 million for the ocean voyage to Asia, for a total of $14 million, which equals the above Mississippi route. There is presently very little grain going along this route. Tracks may not be of high enough quality to carry unit trains consisting of 168 covered hopper cars, each carrying 98 short tons of grain, at speeds of up to 70 miles (130 Km) per hour. To fill one 50,000 ton ship requires three unit train loads. To go back and forth, if all goes well, between Kansas and California takes 4 days. A fully loaded train (rolling stock plus load) represents a capital investment of $20 million. Fig. 2 shows a typical covered hopper car which railroads use to transport grain. The transport charge from Kansas to California is about $3,500 per car. However, reservations need to be made months in advance, a practice which has caused extreme consternations and is generally dubbed as the "Grain Hopper Crisis". Crop yields and harvest times fluctuate, sometimes greatly, according to the weather. As a result, hopper cars are often sitting idle in some locations, and in others they are in short supply. Having reserved them in advance is still no guarantee that they will be there when needed. To the railroads, the cost of delaying a 168-car unit train when empty is $1,000/day and when full $2000/day.

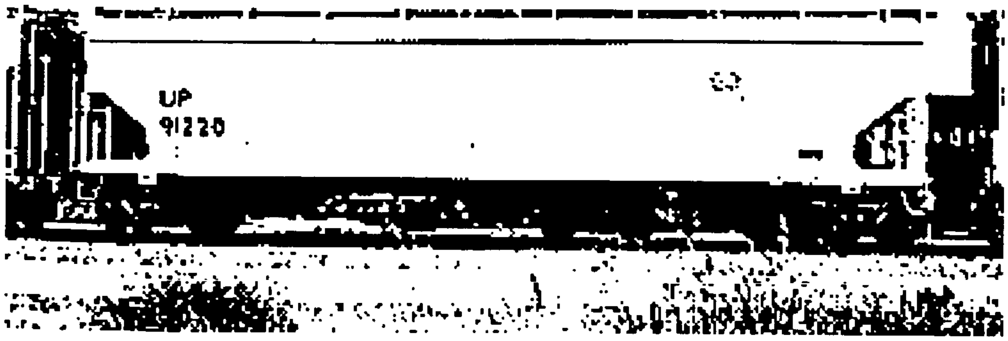

Figure 2. Railroad covered hopper car capable of carrying 98 tons of grain.

Cost Estimate of Shipping to Asia via Maglev Pipeline to California

Unlike the "Cost of Shipping to Asia via Railroad to California" route, a maglev grain pipeline would not compete directly with the Mississippi river route. Instead, the plan is to stay clear of the Mississippi as much as possible, passing through good farming areas and reaching above Kansas to Minnesota. The upper reaches of the Mississippi are often not navigable for long periods of time due to ice, low water levels and floods. These areas are also where farms have frequently failed and land lies fallow because of inadequate or too costly transportation. With an all-weather maglev grain pipeline close by, running unimpeded continuously 24 hours a day, transportation costs to it and storage costs would be greatly reduced, thus creating a boom to the presently economically depressed area.

The cost imbedded in a ship load of 50,000 tons of grain arriving in Asia via this maglev grain pipeline, breaks down to approximately $6 million for the grain producing farmers (as above), $2 million for transportation and storage from farmers' fields to the maglev grain pipeline, $1 million for the maglev pipeline to California and $1 million for the ocean voyage to Asia, for a total of $10 million. This is more than a 25% cost reduction over present modes of transportation, despite the fact that the maglev grain pipeline would be comparatively a high capital investment project. Table 1 shows a comparison of cost distributions of the three routes described above on a dollars per ton basis.

Table 1. Grain to Asia Cost Distribution Comparison, Dollars per Ton

	Via Mississippi River	Via Railroad to California	Via Maglev to California
	$/ton	$/ton	$/ton
Farmers	120	120	120
Railroads & Barges	120	140	40
Maglev Pipeline	-	-	20
Ocean Shipping	40	20	20
Total	280	280	200

Logistic Advantage of Maglev Grain Pipeline over Present Methods

Currently carriers arrive and depart intermittently and irregularly. Therefore, storage facilities (silos) are needed to hold the grain at every transfer point. After harvest, the grain is first stored on the farm. Then it is taken by truck to a railroad, where it is stored a second time. After that the railroad takes it to the Mississippi river to be stored a third time. Then, finally river barges take the grain to an overseas loading dock where it is put into silos for a fourth time.

A maglev grain pipeline is a continuous system capable of running 24 hours a day. Thus, there is less of a need to store grain. Assume a maglev system with 8-inch diameter containers at speeds of 50 miles (80 Km) per hour is in operation. Table 2 shows that it could move grain at a rate of 52,000 tons/day, or 40 tons per minute. Grain is taken directly from farmers' silos to the pipeline's intake hopper and sent directly non-stop to the West Coast where it is stored in silos for the second and last time at an overseas loading dock. Even the West Coast storage may be avoided, or reduced, if ship loading could be organized in a continuous fashion. Hence, with a maglev grain pipeline 50% and possibly 75% of all present silos could be dispensed with. Consequently, cost savings are passed on to grain farmers and Asian consumers.

There are even more savings in this approach. As shown in Figure 1, ships coming in and out of Southern California ports can, like super tankers, be of the largest possible size, 300,000 tons, while the ships presently carrying grain out of non-California ports, due to restrictions in river channels, locks and the Panama Canal, are limited to about 50,000 tons. Hence, one super tanker size ship could take the place of six smaller ships. To take care of all the present grain exports to Asia only two super carrier size ships per week are needed. This would result in reductions in shipping costs.

BASIC COMPONENTS OF A MAGLEV GRAIN PIPELINE

Permanent Magnets in Repulsion as the Means of Suspension

The grain is put into containers which are suspended by permanent magnets in repulsion (ref. 5) as shown in Figure 3. Not shown are lateral guidance controls, which can be either mechanical or magnetic (ref. 6). A particular advantage of using permanent magnets in repulsion is that they require no power to levitate and the containers always remain levitated even when the system is turned off and has stopped. New magnetic compounds virtually last forever in this application.

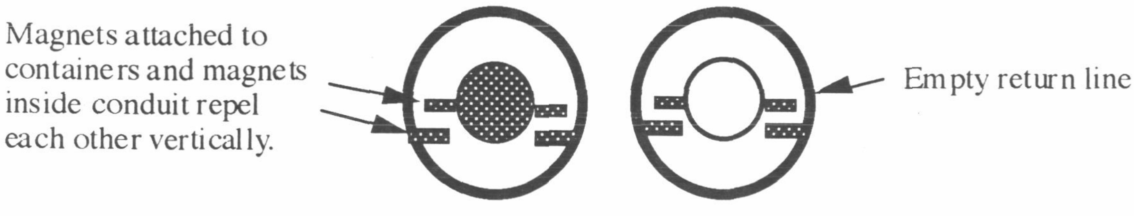

Figure 3. Typical cross section of maglev grain pipeline.

Electric Linear Induction Motors (LIM) for Propulsion

The primary portion of a typical LIM is shown in Figure 4. The secondary to this LIM consists of a metal sandwich or platen attached to the bottoms of the containers. The speed of the shown LIM can be varied by varying the frequency of the supplied power. For instance, the speed can be reduced from 200 to 100 miles (320 to 160 Km) per hour by reducing the frequency from 150 to 75 cycles per second (cps). The LIM can also be reversed for braking. A power supply with appropriate controls would be required to meet the full range of possible operating needs.

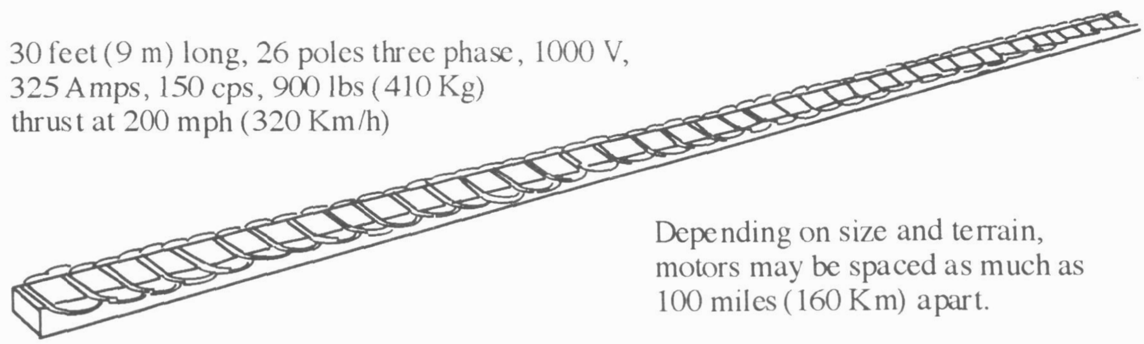

Figure 4. Typical high speed high performance linear induction motor (LIM).

Dynamic Mechanical Loading and Unloading

The containers are flexibly attached to each other end to end and move in unison. A short distance before the end of the line is a cam that forces alternate container joints to diverge onto upper and lower tracks (ref. 7). This causes the containers to fold up against each other and slow down, the last stages of which are shown in Figure 5. After they have completely folded, they pass through either a filling or a dumping station followed by a U-turn. Figure 6 shows a low cost elevated cross-country version of the pipeline.

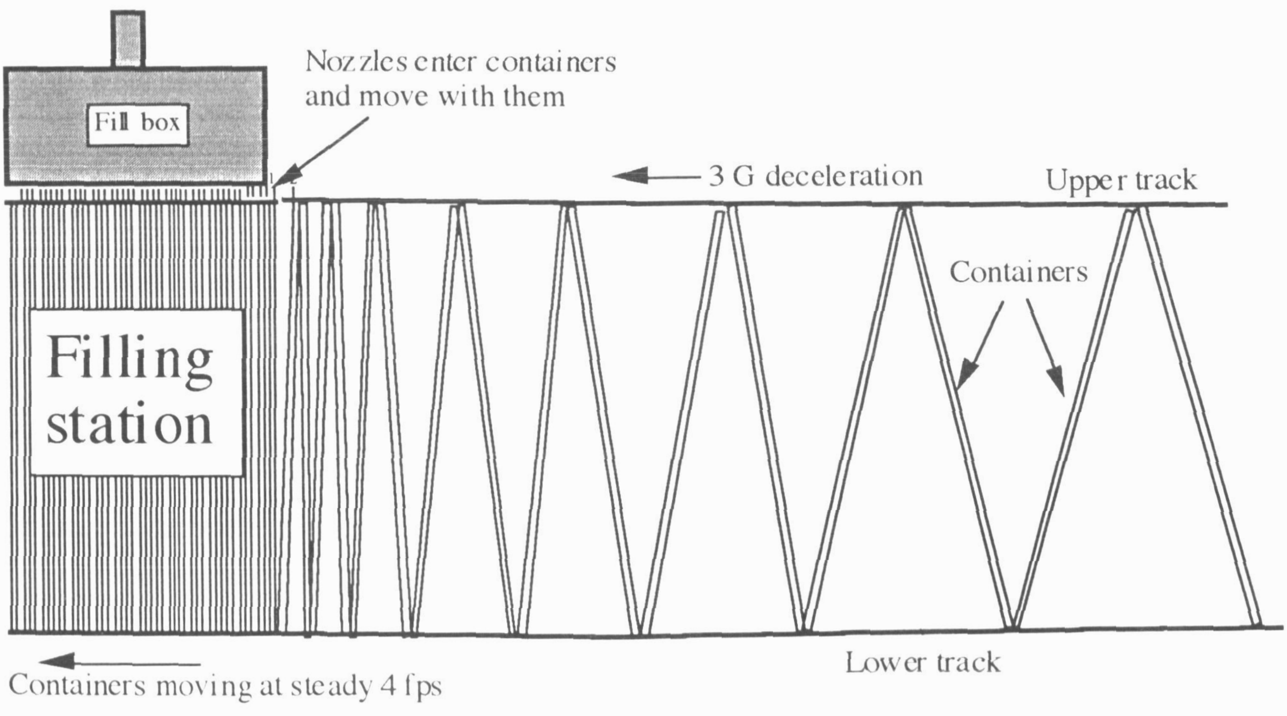

Figure 5. Typical folding and filling of containers..

Comments on Figure 5. Figure 5 is a cutout from a drawing that shows a 200 mph (310 Km/h) system. While this might be a look into the future in bulk materials transportation, initial speeds of between 50 and 100 mph (80 and 160 Km/h) would be advocated with provisions to step the speed up to a higher level later.

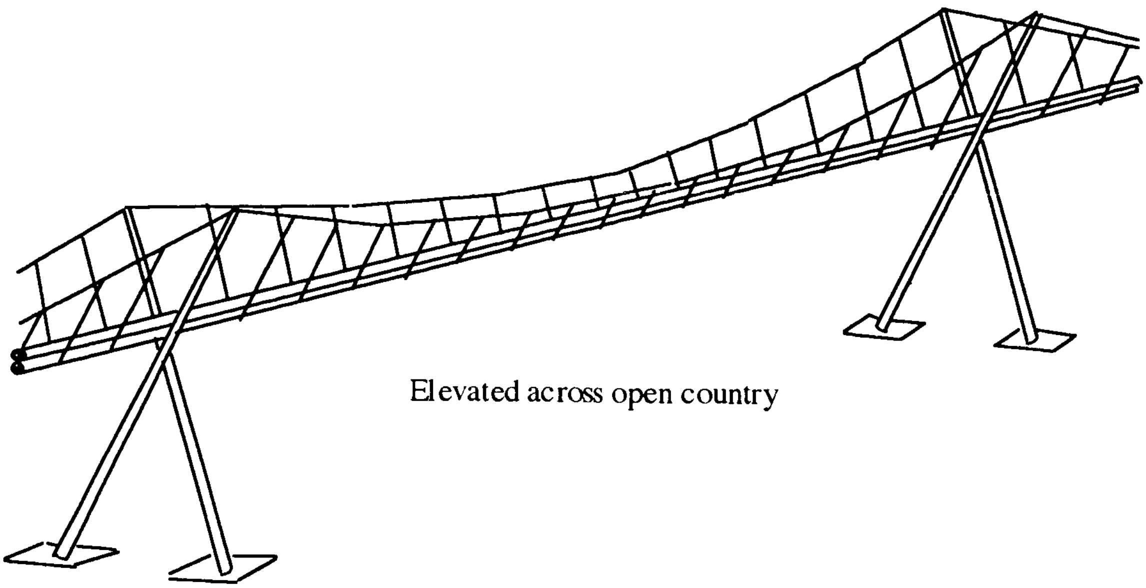

Figure 6. Typical low-cost elevated design of maglev grain pipeline.

SPECIAL REQUIREMENTS FOR TRANSPORTING GRAIN IN CONTAINERS

Unlike the Alaska maglev crude oil pipeline proposal, described in Reference 6, where the only requirement was for the oil to be hot during filling and again during emptying, grain transported in containers should be kept within a specific temperature range and moisture content throughout the trip. When grain is in a condition outside these desirable ranges, the containers should be capable of improving on those conditions. For instance, when grain with too much moisture passes through hot dry regions of Arizona and California, containers should have sensing devices which open vents to remove excess moisture.

Temperature Range. Cold temperatures are generally not injurious to grain. On the contrary, the danger of spoilage disappears when temperatures approach freezing. High temperatures require dryer grain. At about 115°F (46°C) grain with moisture content exceeding 12 percent would suffer heat damage.

Moisture Content. Grain may have from 9 to 13.5 percent moisture. At moisture levels around 12 percent, grain becomes difficult to store for several months. At levels over 14 percent, grain may spoil in a matter of weeks, which is especially true for newly harvested grain.

Insects Removal. While the grain is in the containers, the air around it could be replaced with CO_2 or nitrogen, or a low level fumigants could be added to the air to kill insects.

Ventilation to Reduce Moisture. If grain has too much moisture and when it should also be fumigated, the time available should be shared. The fumigants should be applied first. Then after a few hours, remote controls could trigger vents to open for fumigant to exit and drying air to enter.

MAGLEV PIPELINE COST AND CAPACITY

Construction Cost. A detailed cost estimate shows that, if a medium size maglev grain pipeline had been built in 1996 as an elevated system as shown in Figure 6, it would probably have cost about $500,000 per mile ($300,000 per Km). Not included in this estimate are the costs of (1) right-of-ways, (2) power generators if needed, (3) service roads and (4) end facilities. The elevated design is preferred because of the continued need for very straight alignment similar to overhead electric wires or catenaries of high speed railroads.

Table 2. Assorted Carrying Capacities of Maglev Grain Pipeline, Tons per Day

Container diameter (inches)	(cm)	Speed 25 mph (40 Km/h)	Speed 50 mph (80 Km/h)	Speed 75 mph (120 Km/h)	Speed 100 mph (160 Km/h)
3	7.5	3,700	7,400	11,100	14,800
4	10	6,500	13,000	19,500	26,000
6	15	15,000	30,000	45,000	60,000
8	20	26,000	52,000	78,000	104,000
12	30	60,000	120,000	180,000	240,000

Conversion factors for grain, used in Table 2, are (a) 35 bushels (100 hectoliter) = one ton, (b) 0.8 bushel = one cubic foot (28 liters), (c) grain weight 48 pounds per cubic foot (0.78 Kg per liter).

Size, Speed and Capacity. The carrying capacity of the pipeline is determined by multiplying the container cross-sectional area with the system velocity. The cross-sectional area is determined by the elected container diameter. However, the speed can be changed at any time later which in turn changes system capacity. Table 2 shows the pipeline capacities for various sizes and speeds when running continuously for 24 hours.

FINANCIAL FEASIBILITY

Basic Considerations

In the paper "Maglev Crude Oil Pipeline", Ref. 6, an extensive financial analysis was included to show that if the Alaska crude oil pipeline had been constructed as a maglev crude oil pipeline, as herein proposed for grain, some $10 million per day could have been saved. That analysis was based on recorded financial data as reported to the U.S. Federal Energy Regulatory Commission. This data also shows that the Alaska pipeline was not a true private enterprise because (1) profit was arbitrarily restricted to 6% and (2) interest during construction was not capitalized. The reason for not including these two items on the books was obvious. The Alaska pipeline would have gone bankrupt before it even could have started to operate.

Unlike the Alaska crude oil pipeline, where solid recorded cost data was available to compare with, here, for this proposed grain pipeline project across more than half of North America, there is nothing to compare costs with. All we can go by is the knowledge that two railroads have growing business parallel to the proposed route. One of them moves about 17 million tons/year, and the other is just starting, but may have trouble with inadequate tracks. Their combined present annual income from grain transportation to the West Coast is around $600 million. Additional 33 million tons of grain could be transported along this route representing an additional $1,200 million annually.

Sharing Line with Passenger Service

Not included in considerations of financial feasibility is the likelihood of sharing the maglev pipeline's elevated structure with the light weight passenger transit system, the Knolle Magnetrans (ref. 8, 9 & 10). For instance, the 300 mile portion of the grain pipeline in California may be combined with a Los Angeles to Las Vegas passenger Magnetrans, which could bring in additional gross revenues of $200 million per year. Sharing the grain pipeline structure with passenger service in other locations may also be lucrative. Airlines have long recognized that combining freight and passengers is profitable and keeps rates low for customers.

When Undertaken by Private Enterprise

Figure 6 shows how the 1,500 mile (2,400 Km) maglev grain pipeline across North America would financially fare after construction is completed. Shown are three levels of costs per mile, which could possibly occur, and correspondingly elected freight rates in magnitudes that would assure amortization of capital over approximately 15 years, while paying all require taxes and a return on equity of 20% per year at a debt ratio of 70%.

Comments on Figure 6. A serious effort was made to produce highly realistic data for this graph. For instance, with the pipeline's 1997 estimated cost of $4 million/mile ($2.5 million/Km) and having a length of 1,500 miles (2,400 Km), the beginning of the curve is shown in year one at close to $12,000 million and not $6,000 million (4 x 1,500 = 6,000). This is because estimated inflation of 5% was added during each of the 5 years of construction, and also, estimated annual interest during construction (cost of money) of 15% was included (capitalized) as construction cost. The longer the construction period, the heavier is the capitalized 'cost of money' burden. The construction period was estimated as 5 years. If it could be reduced to 3 years, it would save over $2,000 million in initial capital requirement.

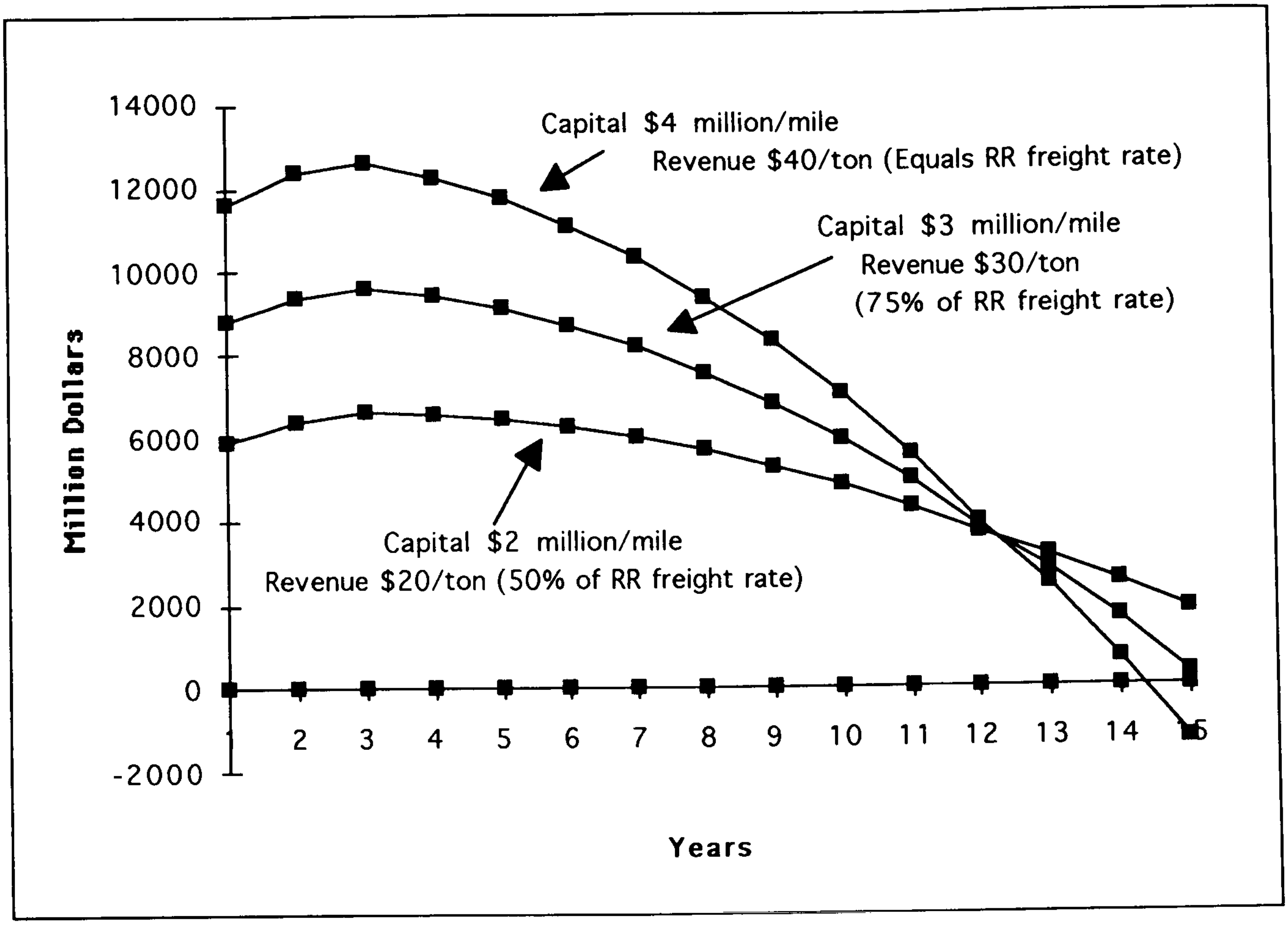

Figure 6. Amortization of capital investment for a 1,500 mile (2,400 Km) maglev grain pipeline from Midwest America to California, assuming capital investment of $4 million/mile ($2.5 million/Km), $3 million/mile ($1.9 million/Km) and $2 million/mile ($1.2 million/Km) with respective revenues of $40/ton, $30/ton and $20/ton.

CONCLUSION

Farm failures are a serious problem in America. The cost of farm equipment, and energy to run it, is rising, but not farm income. Grain transportation, storage and handling costs are excessive. Railroads lack adequate tracks. Maglev pipeline technology could greatly reduce the need for intermediate handling and storage of grain (cut out the middle men), could transport grain more efficiently and reduce overall costs considerably, from which both grain producers (farmers) and Asian consumers would greatly benefit.

Included in this paper is a financial analysis, indicating that a 1,500 mile (2,400 Km) maglev grain pipeline would be financially feasible across the American West. It would be a profitable tax paying enterprise when undertaken by private enterprise.

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