THE VERY HIGH SPEED TRANSIT SYSTEM

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The Concept

The Very High Speed Transit or "VHST" concept was put forward some years ago in response to the search for a pollution-free transport method that could operate at speeds competitive with aircraft. The general principles are relatively straightforward: electromagnetically levitated and propelled cars in an evacuated tunnel.

The VHST is predicated as an addition to the future transportation scene and will offer not only a fast and convenient transit method but also a tunnel complex to house utility transmission and auxiliary freight-carrying systems.

It is assumed that future transportation approaches will be extensions of present ones, including subways for local mass transit and automobiles for the bulk of intracity and intercity travel. Autos have performed over 90 percent of the travel between cities over the last two decades; although it is not predicted that this will significantly decrease, it is expected that there will be improvements in automotive vehicles to make them safer and environmentally acceptable, that there will be improved mass transit (with added "people-mover" systems) to handle local traffic, and that much better interfaces will be established between these modes of travel. The VHST is designed to connect directly with local systems. It is visualized that a passenger steps off a subway (or a people-mover from an auto parking facility) and gets on a VHST vehicle in the same terminal.

The VHST's "tubecraft" ride on, and are driven by, electromagnetic (EM) waves much as a surfboard rides the ocean's waves. The EM waves are generated by pulsed or by oscillating currents in electrical conductors that form the "roadbed" structure in the evacuated "tubeway." Opposing magnetic fields in the vehicle are generated by means of a loop of superconducting cable carrying on the order of a million amperes of current.

The system is highly conservative of energy. The tubetrain is accelerated to its maximum velocity, coasts for a brief period, and then is decelarated. Nearly all the power goes into kinetic energy; in accelerating, it employs the energy of the surrounding EM fields, but like trolley cars of the past, in decelerating, it returns this energy to the system. Its optimized electrical drive system is quite efficient, and further, it does not have to squander unrecoverable energy in climbing to high altitudes, as does an aircraft.

What sort of speeds are needed and how might these be achieved? Speeds as high as 14,000 mph have been examined in studies by the Rand Corporation* (in an example case of a direct link between Los Angeles and New York requiring 21 minutes transit time). The speeds required will certainly be on the order of thousands of miles per hour on the long-haul links.

Because of the rather considerable expense of the tunnels, it is probable that the first VHST system will not rely on a direct nonstop LA-NY link, but rather one that stops at two intermediate staging points. If the route is in several segments, additional flexibility is gained in routing and some latitude is given in the schedule for acceleration. There will be intermediate links in the overall system of up to several hundred miles; in these, compatible speeds will be commensurately lower.

Figure 1 schematically illustrates an overall system. Vehicles from feeder links are phased into the ends and two interchange points of the main coast-to-coast channel. Likely intermediate terminals are Amarillo and Chicago. A search for an optimal routing would present an interesting and challenging problem, requiring an extensive data bank of physiographic information.

There also would be subsidiary lines coming into the two main terminals from such places as San Francisco, Boston, and Denver. The best routing for any particular trip would be shown on a computer display, continuously updated, which would indicate whether a through tubetrain or a combination of shorter hops would be the faster mode.

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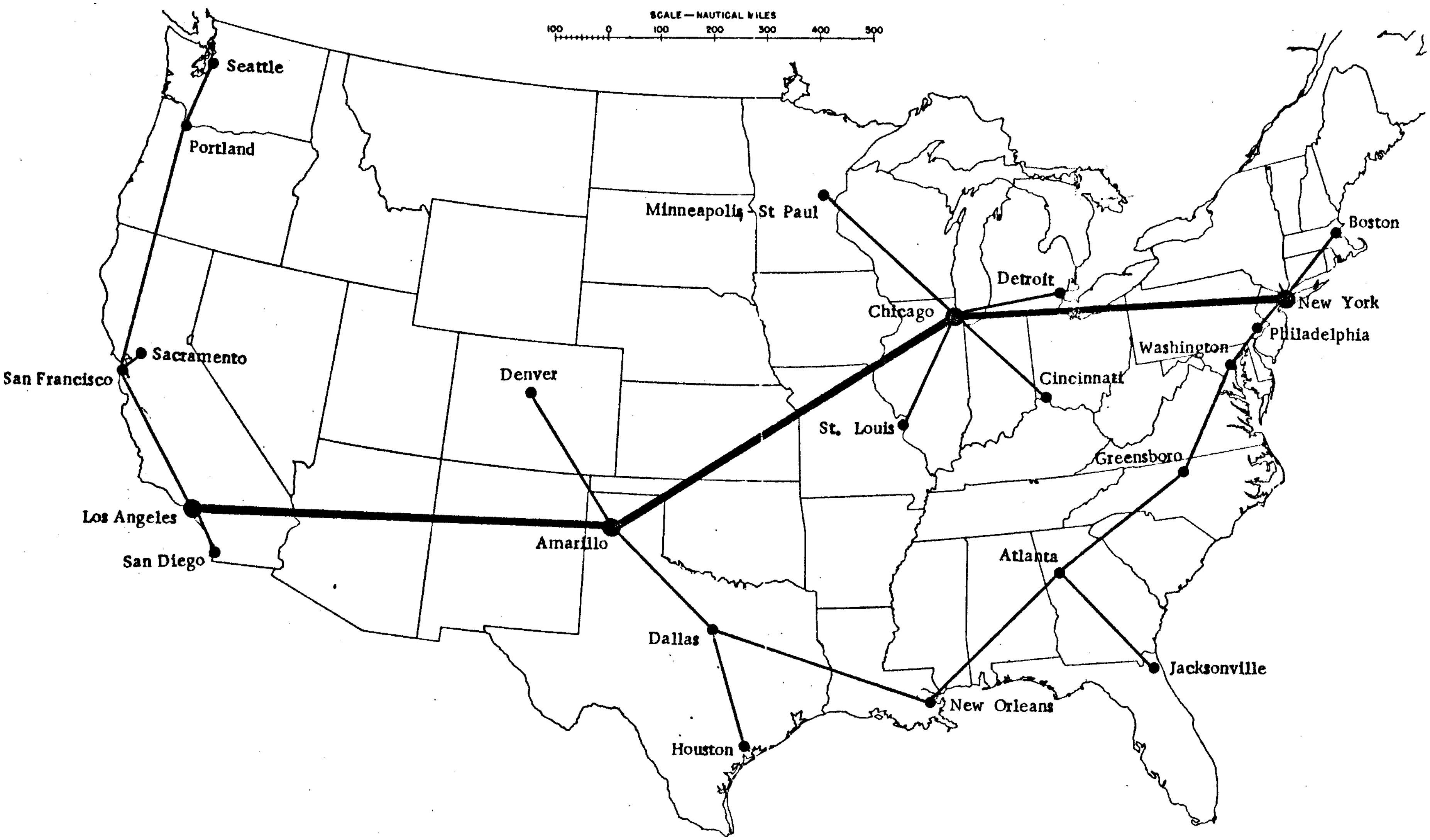
*It should be noted that certain features relating to vehicle control and damping, accommodation of earth tremors, hull construction, and passenger comfort are presently under patent investigation by the Rand Corporation and cannot be discussed here.



The VHST route system

Environmental Benefits

Transportation systems pose well known problems to the environment. The bitter controversy over the sonic booms of the SST has perhaps obscured some other environmental effects of the SST -- and aircraft in general. None of the energy required to levitate and propel the aircraft is recoverable; it all goes into the atmosphere along with combustion products. Long-term buildup of these products in the upper atmosphere is a matter of concern, and is a process that we are just beginning to understand. As aircraft become faster, airports must become more remote and operating altitudes higher, both aspects contributing further to environmental problems.

The use of a tubetrain would alleviate these hazards to the environment; aesthetic considerations, advantageous relocation of utilities, and protection against sabotage would also suggest the desirability of underground tunnels for these systems. Right-of-way costs, surface congestion, grade separation problems, and noise pollution would be eliminated.

Sharing of facilities could help pay the high cost of such tunnels. Included among these contemplated underground systems are pipelines for oil, water, gas, waste disposal, and slurries of materials such as coal and other bulk commodities; communication links, including channels for lasers and microwave waveguides; electrical power transmission lines such as superconducting cables; and passenger and freight-hauling systems.

Superconducting power cables will require a controlled environment to protect the cryogenic refrigeration system that makes superconduction feasible. A controlled-access tunnel is a virtual necessity for such a system. This type of power cable will alleviate many of the problems of siting of future power stations, since they can be located at great distances from the user and yet suffer negligible power losses in transmission. Nuclear reactors, for example, could be located in colder regions and the thermal effects of their cooling effluent employed in such useful ways as to enhance growth in fish "farms."

Laser communication channels along with "repeater" stations will most certainly require the protection of an enclosed channel. Since the tunnels have limited diameter and follow the earth's curvature* while the laser propagates in a straight line, there will be a number of stations needed to refresh and redirect the laser beams. Many thousands of video channels are visualized for these future laser links.

Economic Aspects

Subways are an example of a short-haul transport system that can warrant the costs of underground facilities because of the high volume of traffic that they handle. In the medium-haul regime it would be difficult to build a case for going underground except as demanded by environmental considerations. The question is: Can underground transport be justified on a longer-haul basis? Tentative analyses show that underground long-haul domestic travel can pay for itself, even without mutual economic benefits from sharing the tunnel complex with other underground systems.

Such a system must operate at very high speeds in order to compete with the alternative modes of travel (i.e., aircraft). It further must take advantage of its underground character that permits its integration with local transit systems (i.e., subways and people-movers). The convenience of such an integrated system will help build the passenger volume needed to put the overall system on a self-paying basis.

Economics of the system are based upon high volume induced through overall passenger convenience. Not only does the passenger travel in total indifference to rain, snow, wind, clouds, or heat (a state which no mode of travel on or above the surface can claim), but the time for travel from the heart of one city to the heart of another is radically reduced.

Rand's preliminary investigations have included the above-mentioned cross-country time of 21 minutes, which was a constant one-g acceleration/deceleration, nonstop case. With this same acceleration and with two intermediate stops, the coast-to-coast time would be increased from 21 to 37 minutes. For a passenger traveling from San Francisco to Boston,

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*A tunnel following a chord of the earth's circumference between Los Angeles and New York would be some 200 miles beneath the surface at its midpoint.

the overall time is 51 minutes on a minimum-schedule basis.*

If we postulate 100-passenger cars operating on one minute headways in the central corridor, this amounts to almost 290,000 passenger (or freight equivalent) movements across the country per day. This is on the order of 106 million passenger trips per year. If we take the present total domestic air traffic of 150 million and reduce it to account for the longer-haul portions only, but also increase it for future traffic growth, we arrive at a figure similar to that assumed for the VHST. Another way of looking at it is that this rate is equivalent to cross-country air traffic (including that stopping at major intermediate terminals such as Chicago) of a dozen or so jumbo jets per hour. However, if the VHST offers greatly reduced travel time at a reasonably low fare (say $50 each way), this would undoubtedly cause new travel patterns to develop and perhaps even create a much larger demand than the 106 million/year level. Thus the volume assumed here may be conservative in view of the convenience offered, and since operating costs are only a few percent of the fare, the fare can be nearly halved when the volume is doubled.

Assuming the 106 million/year volume at $50 coast-to-coast fare gives roughly $5.3 billion per year gross revenue, of which (as we will see later) operating costs are an insignificant fraction. On a 30-year payout basis, this means we can afford a $90 billion cost for the central corridor part of the system. This works out to be about $30 million/mile of double tube system.

Since the amortized cost of the facility is the overriding factor, we might consider adding additional VHST cars solely for freight purposes. With a 12-fold increase in volume (five-second headways), freight costs would be around 1¢ per ton-mile. Many freight items, including automobiles, could be carried this way. On this expanded-volume basis a traveler could take his car with him for a fare about the same as that for a passenger alone in the previous case.

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*He would have a number of options, and computer displays would present the alternatives, e.g., wait for the next scheduled San Francisco-to-Boston car, take a scheduled New York car and disembark for the next New York-Boston run, or change in both Los Angeles and New York. There are, of course, other possibilities involving changing cars at the Texas and Chicago interchanges, given the system shown in Fig. 1.

A complementary steel-wheels-on-rail, 100-mph, heavy freight system that readily interfaces with railroad systems and collocates with the VHST tunnel complex is described later. This latter could move 7 million tons of freight across the country daily. Joint use of the tunnel complex, as previously discussed, will reduce the effective cost for any one user.

Technical Aspects

The most demanding technical problem is that of lateral accelerations. A vehicle traveling at 550 mph cannot undergo sharp turns. In order to keep the magnitude of these sideways forces down to one g (i.e., equal to the vehicle's weight) the radius of bend of the track cannot be smaller than 4 miles. At 5500 mph this radius must be greater than 400 miles. This requirement imposes strong constraints on the design of the guideway and would create a great difficulty if one attempted to run the VHST tubes above ground.

On the other hand, locating the system underground can overcome this difficulty and has a number of contingent benefits, particularly those of environmental improvement discussed above. Furthermore, even at the present time, when considering grade crossings, right-of-way costs, etc., the cost of a tunnel is not significantly greater than that of a surface system -- and this doesn't take into account potential decreases in tunneling costs through use of new technology.

Once the assumption is made that underground tunnels are necessary in order to travel at speeds competitive with present (and future) aircraft, another aspect of the problem becomes evident. Over 90 percent of the system cost will result from the tunnel itself. This situation applies even if very expensive guideway and vehicle hardware is employed. This then suggests that we can afford to incorporate very sophisticated transport systems into the tunnel if these systems contribute to increased utilization of the tunnels in even a small way. The fact that these sophisticated approaches offer a much greater increase in system capacity sets the optimum cost tradeoff at the high-speed end of the spectrum.

In order to attain these high speeds we cannot follow conventional avenues. Even the presently DoT-supported magnetic levitation (MagLev) schemes (which utilize passive guideways) are inadequate. What is needed instead is a fully active guideway system that is highly precise. Every point in the vehicle's trajectory has an exact design condition that must be met -- only minor excursions are permitted, and these are continuously corrected for. Thus, for example, at mile 427 the design requirement might be for a speed of 723 mph at a thrust angle of 47.8° and a thrust force of 1.38 g. Every car as it passes this point must meet this precise requirement.

Careful matching of the thrust vector at every point along the way will yield high efficiency. Use of a superconducting current loop in the vehicle to oppose the driving fields of the roadbed stator conductors will provide for a substantial clearance (of the order of a foot), which is needed in vehicle control at high speeds. The optimized matching process will reduce make-up power into the vehicle's conductors to a very small amount. Cryogenic fluids (to keep the vehicle's conductors at superconducting temperatures) will not be actively refrigerated underway but will be replaced at terminal points. Boil-off will be stored enroute and recycled at terminals during "turnaround" of cars.

The conductors in the guideway are heavy bus bars, and currents are properly phased to levitate, propel, and control the vehicle. Different EM wave forms and propagation methods have been considered. The most effective mechanism is a traveling wave, but it requires triggering circuits and pulse-forming networks. The standing-wave approach requires less electronic hardware but takes about twice as much current (on the average) in the stator conductors. A detailed tradeoff analysis of these choices has not yet been made.

Another tradeoff exists in the amount of atmosphere in the tunnel. High vacuum would require expensive diffusion or ion pumps and much power. On the other hand, too much air will create drag and heating problems. A good compromise is to use vacuum "roughing" pumps only, to pump down to a pressure of about 0.5 mmHg (equivalent to 170,000 ft altitude).

At these pressures the air molecules essentially travel on independent paths (Newtonian flow condition) and the vehicle drag is a function of the presented area only. Streamlining is thus not required. Heating takes place only at the nose and this is negligible. However, there will be a heat shield incorporated to protect against heating caused by air in the tunnel should a major leak occur. If the final design requires that the cars be cooled, a self-contained heat reservoir can be used that is recharged during turnaround.

Assuming a pumpdown to a vacuum of 0.5 mmHg in approximately nine hours, the 5,000 miles of vacuum shell would require only $78 million in pumps (two 2600 cfm roughing pumps per mile). Furthermore, there would be considerable over-capacity for handling leakage. (Normal leak rate is estimated at 77 liters/sec/mile.) The power to maintain the vacuum is not negligible and is of the order of the operating power for the cars. (Total power cost, on the other hand, is small compared to fare revenues or amortized system investment costs.)

At terminal points there must be a quick-opening gate (or gates) and differential pumping to maintain the tube vacuum. Guillotine-type doors can be considered and can be automatically timed for the passage of the vehicle. The door would be somewhat larger than the enclosure so that it could be set in motion before actual opening or closing. Some sort of a compliant, labyrinth structure can be used to minimize clearance between vehicle and enclosure at the vacuum locks. The vehicle's speed in this regime is low and optimized to produce the most satisfactory solution to the vacuum-lock problem.

Tunneling Considerations

As mentioned above, the lateral-acceleration problem is one of the most difficult of the VHST problems. Assumption of the use of tunneling will greatly alleviate the problem of proper selection of a routeway to minimize lateral accelerations -- particularly in the very high speed regimes. Even if tunneling does not provide the minimum cost solution, it probably will permit minimizing transit times and environmental disturbance. Thus both for passenger convenience and for environmental quality, there would be strong justifications for an all-underground VHST system. To this rationale can be added the joint benefits from an underground utility network, other transportation systems sharing the complex, and the potential for defense purposes.

At the first International Advisory Conference on Tunneling, sponsored by the Organization for Economic Cooperation and Development (OECD), designed to stimulate more rapid progress in tunneling technology, it was brought out that the technology of tunneling offers great potential for alleviating a wide range of problems related to urbanization.* At least 8000 miles of tunnels were constructed in the 1960s, and a survey report showed that demand for tunnel construction in the 1970s will be at least double this figure.

It is difficult to estimate tunneling costs accurately because the technology is rapidly changing. A recent study for the Office of High Speed Ground Transportation (OHSGT) of DoT suggested that the various future needs for tunnels will create a demand that will cause a reduction of 30 to 50 percent in tunneling costs and an increase in tunneling advance rates of 200 to 300 percent. These improvements can be achieved only by consistent development in all facets of tunnel construction. New techniques under development involve a systematic and more automated matching of excavation techniques, tunnel support installations, transport of excavated material out of -- and construction materials and personnel into -- the tunnel, liner construction, and environmental-control concepts.

Inherent limitations of the cyclic or conventional method of tunneling suggest that the new approaches must include continuous or semi-continuous excavating machines. Augmented rotary drills, e.g., turbine drills and vibrating-bit drills, have shown some promise. These have demonstrated sustained advance rates of 200 ft per day with short-duration rates of 400 ft per day. They are also capable of drilling holes of perhaps 10 m diameter. Their drawbacks include the

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*Engineering News Record, July 2, 1970.

difficulty with which bits are replaced and the frequency of such replacement, resulting in more than 50 percent down time. They also experience difficulties in very hard rock formations, e.g., igneous rock.

High-pressure water jets have been tried as so-called erosion drills. With these, power requirements are high, and present designs experience severe nozzle erosion; the necessity for wall and roof support provides another major problem. Other erosion drills employ abrasive jets using sand or other abrasive materials, even steel pellets; these have been found inefficient and of low speed.

The use of explosives in shaped-charge blasting shows good promise, although the advance rate is slow, and personnel and equipment operating close to the working face must be protected. Explosive drills, which employ small charges set off near their tips, have proved high in cost, although they show good penetration except in soft or plastic rocks.

The "jet-piercing" or flame-jet drill is an example of a proposed spallation drill. Lasers, electron beams, and acoustic transducers have also been investigated. These spallation methods too encounter difficulties with igneous formations. Laser photons and electrons can be made energetic enough to melt their way through rock, but the process is highly energy intensive. The "compacting auger," which is essentially a wedge continuously driven forward, needs excessive force to operate and is limited to highly porous or unconsolidated material. Chemical softening of rocks might prove useful to condition the material for conventional drills; however, handling difficulties preclude using chemicals for complete removal of rock.

All of the above methods of drilling present the problem of debris removal, especially the faster ones where the removal system is constantly lengthening at a high rate of speed. Two systems have been proposed that hold some promise, according to the aforementioned OHSGT study:

1. The side-wheel powered drive concept which consists of trains of cars running on rails, propelled by stationary motors driving pneumatic-tired wheels acting against the sides of the cars.

2. The hydraulic muck transport system for both horizontal and vertical transport of muck, operating in conjunction with

either rail or truck haulage for the transport of incoming construction materials.

Perhaps the most promising drilling technique of all, however, and one which provides its own debris-removal system, is the rock-melting drill currently under investigation at the Los Alamos Scientific Laboratory (LASL). In preliminary tests, rock-melting has proved to have a very high advance rate, is efficient in most kinds of rock (especially igneous), does not rotate so that the hole can be created in any shape, would not endanger personnel, and creates its own lining of strong, glass-like material. This latter ensures that there need be no constant shoring-up of walls and ceilings of tunnels, as well as provides a pressure-tight, impervious lining.

The energy source for the rock-melting drill (dubbed "Subterrene" by LASL) is electrical or nuclear. The latter version is compact and self-contained and would be used in large tunneling operations. It requires 50 MW power, based on 25 percent melting (only an annular region of rock is melted, the rest removed as core). The drill itself is tungsten or a niobium-zirconium alloy. The advance rate is predicted at 100 m/day or 12 ft/hr, significantly faster than any other proposed drilling method. Further research has been proposed on a laser system for guidance or development of subterranean telemetry or self-contained pre-programmed guidance systems.

The debris-removal problem is eased by the formation of the glass lining from some of the rock. Molten rock is forced into cracks in the surrounding formation as well, adding strength and eliminating still more debris. The remainder of the excavated material is either removed as scoriae via a helical debris conveyor contained in the drill apparatus itself or may be extruded as a glass-covered core (which, cut into usable sections on the spot, might be easily transported to construction sites on the surface).

It is evident that with the above-mentioned advances in drilling and tunneling technology, the most appropriate and efficient method could be found for advancing through each type of rock or soil found along the VHST routeway. Cost tradeoffs would have to be studied in the light of geologic information on each region. Tunneling could begin in one area with one type of drill concurrently with other areas and other types of drills.

Exploration and mapping of geologic formations on a vastly expanded scale over existing data will be necessary for the VHST. Use of smaller versions of the Subterrene to drill test holes will facilitate a program of this magnitude.

Each of the above modes of drilling (except most of the Subterrene cases) requires that a tunnel lining be used. Prestressed high-strength concrete is a candidate both for the tube's vacuum shell and for tunnel lining. In previous Rand studies of linings of tunnels for defense purposes, the prospects were discussed for using 10,000 psi concrete, with distributed polymers and irradiated for bond strengthening. Rand has also recently investigated very high flux particle accelerators, which could be applied to make manufacture of such high-strength concrete an economical process.

However, even present-day prestressed concrete might be suitable. Nine-foot concrete pipe conduits for the Feather River Water Project were contracted for at $182/ft, which would equal less than $5 billion for 5,000 miles of vacuum shell. Such concrete may be dense enough for vacuum purposes, but if not, wall coating with plastic or glaze could be considered. Joints are probably simple sleeve clamps over O-ring type packaging with some allowance for cocking of one tube section relative to the next for alignment changes. Constraint in the longitudinal direction is considered unnecessary.

It is noteworthy that tunneling at great depths is not much more difficult than tunneling at shallow depths.* In fact, it may be somewhat easier since the rock at greater depths may be more competent and consistent. This fact makes it conceptually possible to consider tunneling under deep water. A tunnel following the great circle route from Seattle to Paris would not require going under any ocean deeps, and in fact, would be under land masses most of the distance; the maximum depth requirement would be generally less than one mile.

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*Rand studies of tunnels for hardening of defense installations indicate that except for the additional lift at tunnel ends for material removal, there should be little difference in tunneling at 5600 ft versus 200 ft depth.

A Companion Freight Transport System

The development of a routeway for a VHST system would offer the potential for the collocation of an advanced freight transport system (Fast Rail System or "FRS"). Such a system would be designed to interface with existing railroads and to carry semitrailers, container cargo, campers, and items too bulky to fit the configuration of the VHST cars. Its guideway would be collocated with VHST tunnels and share power and service installations.

The FRS could consist of a transcontinental link plus several cross links. Trains would probably travel at 100 mph, would be highly streamlined, electrically "driven," and would comprise a dozen or so cars, each of which would be large enough to hold a standard railroad car. (Cars could be of different sizes to accommodate various railroad car sizes or other cargo.)

At 100 mph, with a well streamlined train, the required power per car is about 100 hp, about equally divided between rolling and air friction. (Wheeled support is probably the best choice at this speed and for this purpose -- although a Tracked Air Cushion Vehicle (TACV) might be found more cost-effective in a tradeoff of power consumption versus investment.) Some additional power is needed for station-keeping and for climbing grades. To accelerate to 100 mph in a reasonable distance would require several hundred horsepower per car. Gravity might be used to bring cars up to speed from the marshalling yards and to decelerate them upon return to the yards; a drop of about 300 ft is needed for the acceleration considered. However, this added constraint on rail facilities may be more costly than the additional installed electrical power needed without gravity acceleration.

Loaded standard railway cars would be inserted into tube cars at marshalling yards. The tube cars in turn could be assembled to form a train of contiguous surface while being accelerated to tube speed or individually could be phased into a train in the tube. The cars would be interconnected to form trains of length sufficient to reduce air resistance. The trains can be reformed with only slight speed changes to isolate a slot to add or discharge a car from the system. Input/output maneuvers could be performed at any point where the roadway altitude was compatible with surrounding territory, making FRS available to cities and areas where no VHST terminals exist.

Trains would be closely spaced and under phase-locked control. Coast-to-coast would take about a day in transit, which would obviate the need for transcontinental trucking and cut into many air-freight requirements. It would be a boon to container shipping, offering the long-sought "land bridge" coast-to-coast link.

Concluding Remarks

We have noted that the VHST system operates in its own rarified atmosphere at or below ground level, in contrast to high-speed aircraft, which must climb to altitude in order to operate in such an efficient regime. Most of the VHST cases considered at Rand took less time to go coast-to-coast than an aircraft would spend in climbing. Also the VHST's efficient use of electrical drive will permit recovery of most of the power expended in accelerating the vehicle, since during deceleration it is braked electrically, returning energy to the power lines. Thus the environment is benefitted both because the VHST is energy conservative and because it does not dump exhaust products and noise into the atmosphere.

Other environmental benefits seen are those accruing from collocation of utilities and a companion freight system in the VHST tunnel complex.

The technical problems associated with the VHST development are manifold and difficult -- but no scientific breakthroughs are required. Critical areas include tunnel alignment, vehicle lateral acceleration, vehicle control and damping, and the tunneling process itself.

The Ralph M. Parsons Company undertook a comprehensive analysis of the VHST, donating their efforts to Rand because of the future promise they believe the VHST offers. Their study assumed the use of the drill-and-blast method of tunneling as being best suited for the greater part of the route, and using shaped charges placed in pilot holes drilled by water jet. Further, Parsons analyzed the power requirements and did preliminary design of underground electrical systems, including dedicated power stations. (Interestingly enough, fossil fuel and nuclear reactor approaches showed comparable costs.)

Since the tunnel facility cost is an overwhelming portion of the total VHST system cost, there is need for it to pay for itself through high-traffic volume. Parsons showed that the electricity needed will cost less than $1 per passenger trip. On the basis of relatively low operating costs versus system fixed costs, it may be seen that the $50 fare per passenger trip based on 100 passengers leaving each coast per minute might be reduced to perhaps less than $10 if the traffic volume increases by a factor of 10. Of course we cannot accurately forecast the future demands on the system -- we can only speculate. Studies indicate, however, that with the availability, speed, and single-modal convenience offered by the VHST a high utilization rate is indicated. For example, a New Yorker could get off a subway, get on a VHST, and be in Los Angeles in less time than it now takes him to get to J. F. Kennedy airport. He could leave at lunch hour for a "morning" meeting on the west coast and be back home by quitting time. It is probable that some day we might even be able to link up American and EuroAfro-Asian systems by tunnels under the North Sea via Greenland and Iceland and via the Bering Strait.

Will such a system ever be developed? It should be said that the political outlook is much less optimistic than the technical one. For one thing there is no jurisprudence bearing on the freedom of underground movement akin to that for the skies and the high seas. History has shown that some obvious projects, such as tunneling under the English Channel proposed in the time of Napoleon, can be delayed for centuries because of political pressures. On the other hand, relatively primitive societies were able to achieve such engineering feats as the pyramids with a much larger proportional bite out of their gross national product than is posed by the VHST on our present GNP of $1.1 trillion. One interesting aspect that may be politically appealing is that the VHST tunneling job can be done many places simultaneously, utilizing local community resources.

Are there compelling reasons for the VHST? The answer to this is an emphatic yes!! We no longer can afford to continue to pollute our skies with heat, chemicals, and noise, nor to carve up our wilderness areas and arable land for new surface routes. Nor can we continue our extravagant waste of limited fossil fuels. We need to get the bulk of truck traffic off highways and free these routes of much of the commuter auto traffic in order to restore to motorists the pleasure and convenience of driving through the countryside.

Is the VHST system really far-fetched? In order to gain proper perspective, it is instructive to look back over the last 100 years in transportation and see how far we've come.

However, in those 100 years, modes of transportation have proliferated with little or no attempt to integrate one with another. The efforts to move efficiently, safely, and sanely (environmentally speaking) both people and goods throughout the United States should be coordinated and plans made for this coordination as soon as possible. The VHST is specifically designed to be integrated with other existing and proposed transportation systems. Local rapid transit districts, utility companies, and transport authorities should be planning now to implement such an integrated system; the VHST would be a fitting starting point for such plans. The VHST concept has been advanced, the technology is presently available; needed now is the considerable research effort leading to the formulation of final, concise plans for its accomplishment.

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