<u>INDUCED DEMAND</u>: MATCHING THE ATTRIBUTES OF MAGLEV WITH THE INFORMATION AGE INTER-ACTIVE MEGALOPOLIS

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***Abstract*---Continuing economic, social and cultural trends spurred by the Information Age and stimulated by the expectations of the Knowledge-Based Society are pushing commuters to travel further between the inter-active regions within a Megalopolis cluster, blurring intra-urban and inter-city distinctions. Worldwide, changes in the nature of work and advanced telecommunications and transportation links are precipitating the fusion of clustered metropolitan regions into a network of linked cities called the 'Inter-Active Megalopolis'. The dynamic Shanghai-Hangzhou area has potential to be such an Inter-Active Megalopolis as it tailors itself to the Information Age. Only a surface transportation system with off-line stations and using elevated guideway non-contact MAGLEV technology with its superior speed, safety, reliability, environmental acceptability and capacity is compatible with the expectations, life style, rapid accessibility and enhanced transportation demand of the Information Age. The thesis of this paper is that this demand for increased accessibility will primarily be due (in transportation engineering terms) to 'induced travel demand', that is, new ridership. This induced demand creates ridership 200 to 400 percent more than traditional planning methods predict. Little diversion from other modes to MAGLEV is expected.**

1. INTRODUCTION

The Information Age, which the world is rapidly entering, is the result of the convergence of computer and digital communications to permit instant worldwide transmission of voice, text, data and images. In its capacity to effect societal changes, the Information Age is being compared to the Industrial Revolution. In addition to transforming the economy and the nature of work, the impact of these changes is redefining the scale and nature of the urban form. Worldwide, changes in existing urban form and community links are precipitating the fusion of clustered metropolitan regions into a network of linked cities called the 'Inter-Active Megalopolis' [1]. The dynamic Shanghai-Hangzhou area (and possible extension to Nanjing and nearby cities) has potential to be such an Inter-Active Megalopolis as it tailors itself to the Information Age.

The trends spurred by the Information Age and stimulated by the expectations of the Knowledge-Based Society are pushing commuters to travel further between the inter-active regions in a Megalopolis cluster. Commuters worldwide prefer to be able to access their destination from their residence within an hour, be it to their work site, to a business meeting or for shopping, recreation or entertainment. Unfortunately, no existing conventional transportation system technology can significantly reduce the commuting time for people working and interacting in Megalopolis clusters. In both industrialised and developing countries, road transport capacity is at (or approaching) saturation levels, conventional rail is constrained and distances are too short for effective air operations. New access and mobility enhancing technologies to overcome the shortfalls of conventional modes are telecommunications and High Speed Transport (be it high speed steel-wheel-on-rail, automated highway systems or tracked magnetically-levitated vehicles, known as MAGLEV). The authors' judgment is that only a surface transportation system using off-line stations and elevated

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guideway non-contact MAGLEV technology with its superior speed, capacity, safety, reliability, maintainability and minimal impact on the environment is compatible with the high expectations, mobile life style and easy and quick accessibility that the Information Age connotes. This symposium's topic of a MAGLEV transportation system intended to permit *"Traveling from Shanghai to Hangzhou in just 30 Minutes"* fits exactly with the expectations of commuters in the Information Age.

Technically, MAGLEV with an elevated guideway and off-line stations can more readily be superimposed onto an existing urban and regional community form than any other high speed surface transport means. The significance of off-line stations is that the design capacity of a transportation system can be more readily matched to ridership origin and destination requirements plus offer a higher level of service to the user. The challenge, however, is how to predict the ridership of such a totally new transportation technology as MAGLEV, especially in the evolving Information Age context when there is no direct precedent from which to base an extrapolation. This projection and the fare pricing policy are key factors in the economics to justify constructing the infrastructure for a MAGLEV system. Conventional transportation demand modeling will predictably arrive at ridership numbers too conservative to justify the large investment in a MAGLEV infrastructure.

The thesis of this paper is that the demand for increased accessibility permitted by a MAGLEV system in an Information Age / Inter-Active Megalopolis context will primarily be due (in transportation engineering terms) to 'induced travel demand', that is, new ridership. In the experience of the authors, 'induced demand' will create ridership levels 200 to 400 percent more than that estimated by traditional planning techniques. Only a minor transfer from other modes to MAGLEV is expected. Hence, planning will have to be on a normative versus extrapolative basis, that is, envisaging the economic and social activities plus behavior and expectations of a dynamic Information Age society in, say, the Year 2020 (encompassed by the expression '2020 Vision').

2. DEFINITIONS

To facilitate the development of the thesis of this paper, definitions of the principal expressions are given herein:

-Information Age: the current era in the world's history characterized by the rapid introduction of high speed digital communication networks linked to computers for the near-instant global transmission of voice, text, data and imagery. A distinction of the Information Age is that the cost of knowledge labour is greater than the cost of fixed investments.

-Knowledge-based Society: an expression characterizing a post-industrial society having occupations primarily involved with generating products, processes or services which have a high knowledge content, and hence are researched, developed, produced, deployed, used, serviced and enjoyed by a population having a high education level or specialty labour skills. Those working in such sectors are called 'knowledge workers' and live anywhere.

-Metropolis: the Greek word, 'Metropolis' means 'Mother City', connoting a powerful city that exerts an economic and protectorate influence over neighboring smaller cities, towns and villages. The word 'polis' means a city, an urban area where citizens can work, live, study, play and worship. Metropolises that evolved in the first half of this century owe their urban form mostly to public transit such as the tramway, commuter rail and subway linking surrounding communities to the 'Mother City'; more recent ones conform to the automobile / road system.

-Technopole: a geographic concentration of rivals, customers and suppliers that promotes efficiencies and specialization via regular interchange and cooperation with industry research and development efforts. Metropolises are too confining an urban form to sustain growing urban agglomerations for the Technopole.

-Megalopolis: the term 'Megalopolis' defines an extended urban complex that comprises several large metropolises and their metropolitan areas (such as Boston-New York-Washington, Tokyo-Nagoya Osaka, Montreal-Ottawa-Toronto, or Paris-Brussels-London as examples).

-Inter-Active Megalopolis: the geographical entity that is made up of a series of metropolitan complexes or 'urban islands' that are linked by telecommunications and transportation, and hence, interact synergistically with each other. The importance of the adjective 'Inter-Active' is that in the Information Age, there is an expectation to be able to quickly and easily transfer electronically and physically within the Megalopolis.

-MAGLEV: an acronym for a tracked mode of passenger transport that utilizes either electromagnet (attraction) or electrodynamic (repulsion) forms of levitation technology for the non-contact suspension, guidance and linear motor propulsion on an elevated guideway. High speed versions can have operational speeds up to 500 km/hr.

-Transportation Demand Modeling: the quantitative basis for estimating the ridership for new transportation services. Conventional or 'extrapolative' modeling methods project future ridership based on modal diversions using historical data; their variables are primarily trip time, fare cost, frequency, and modal preferences. Most models ignore the spatial dimension in transportation planning by separating travel markets arbitrarily into intra-urban and inter-city. This separation overlooks the spatial changes in trip behavior thus underestimating ridership.

-Induced Travel Demand: the ridership generated or 'induced' as a result of the introduction of a new transportation service. This ridership is additional to that attracted from other modes of transport. The estimation basis is 'normative', that is, envisaging the economic and social activities plus behavior of a population twenty years hence and quantifying these needs to work backwards to estimate the demand (induced by the envisaged activities) and subsequent justification for sizing of the infrastructure and service level. Induced demand modeling accommodates the spatial dimension, that is, trip length, thus blurring any separation between intra-urban and inter-city considerations. This tends to more effectively reflect the urbanization reality of the evolving Inter-Active Megalopolises, the widespread use of telecommunications and expanding separation of work and residence sites.

3. TRANSPORTATION IN THE INFORMATION AGE

Worldwide, the urban form is experiencing its greatest transformation since the mass production / mass consumption industrial era which started in the 1940's and 1950's. Advancements in telecommunications and expansion of the transportation network are the underpinning technologies or enabling means to achieve this new urban form and new economic activities. A current reality, however, is that advancements in telecommunications are far outstripping advancements in transportation. In fact, in many metropolitan areas worldwide, whereas the ease and speed of communicating via cellular telephone or transferring data or multimedia via the Internet or World Wide Web have advanced exponentially, transportation has not kept pace. In fact, commuting time and ease have deteriorated. Only MAGLEV transportation technology is seen to have the features compatible with the advancements and accessibility expectations of the Information Age and interests of the Knowledge-Based Society.

There has been much debate regarding whether telecommunications and telematics (tele-conferencing, teleworking, tele-education, etc.) will be a substitute for travel and shipping. In the authors' experience, there is a complementarity between telecommunications and transportation, that each induces expansion of the other. Telecommunications provides some substitution for physical transport but the overall result is an increase in both activities. Communications makes for more transportation and more transportation leads to more communications. It is analogous to the take-up of the computer with its promise of a paperless society. Everyone can observe that the widescale adoption of the personal computer has 'induced' an exponential rise in the use of print on paper. Similarly, the negligible cost of using the Internet (the development cost for which was absorbed initially within the USA military budget) has induced an exponential access to transportation-related information, be it to facilitate travel itineraries, ticket purchase or waybill tracking by industrial users. However, in both these analogies, the new technology provided actual and perceived benefits to users, which caused the users to change their habits; one such spin-off being increased transportation ridership. MAGLEV is as a generic technology to induce similar changes.

It is observed that newly-modernizing economic regions (of which China has several) are leap-frogging into the Information Age. The profusion of cellular telephones in regions where the plain old dial telephone never existed attests to this. The same logic can be used to project how transportation can keep pace with telecommunication developments. These newly-evolving regions could, similarly, leap-frog to the transportation technology that is judged the most compatible with the Information Age, that is, MAGLEV. An Inter-Active Megalopolis which possesses high accessibility based on the combination of an advanced telecommunications infrastructure and a MAGLEV-based transportation system will have a distinct competitive advantage, domestically and internationally. These attributes will attract international investment, a key ingredient to incremental economic growth. *This could very well be the scenario by the Year 2020 for the Hangzhou - Shanghai relationship served by MAGLEV transportation, that is, knowledge workers could maintain their residence in Hangzhou (and enjoy its physical and cultural splendors) while having an employment base in Shanghai (and enjoy the economic vitality of this megalopolis).* Regions that can best increase accessibility while at the same time manage the environmental, social and economic costs of meeting the demand for increased travel will prosper in the Information Age, while others which are less successful will suffer economically in the global competition for knowledge-based investment.

By its very nature, MAGLEV technology is compatible with the knowledge-based skills predominating in the Information Age [2]. Its non-contact suspension, propulsion and guidance configuration means that the heavy labour-intensive maintenance of roadways or conventional railway technology with its wheel-rail interface is not a burden to be borne by subsequent generations. The noise, vibration, friction and wear of wheel-to-rail or wheel-to-roadway are eliminated [8]. The skills for maintenance and operations are more akin to those of electronics or telecommunications infrastructures than for conventional transportation. Its automated (computer) control coupled with the elimination of any physical vehicle / guideway contact ensures a level of speed, headway control, operational effectiveness, efficiency, safety and reliability not possible in other modes. Its elevated structure means that it is more easily superimposed upon an existing urban and community form and can accommodate gradients up to 10 percent. The elevated structure eliminates the at-grade barriers and massive bridge structures of conventional railways and permits agricultural activity to continue unimpeded below it. The guideway can be used as a visual enhancement if otherwise unsightly telecommunications and electrical transmission cables are integrated with it. Its routing within a metropolitan complex can be more readily matched to the origin-destination ridership requirements, especially if off-line station designs are adopted. Snow and ice conditions do not impede MAGLEV.

4. SERVICE ATTRIBUTES FOR MAGLEV TRANSPORTATION

"Faster than automobile and rail transit but more convenient than an airplane"

A successful MAGLEV application will be one that can emulate the airlines' inter-city travel time (for distances up to 500 kilometers) as well as the convenience, ease of use and time-reliability of an intra-urban mass transit service. In such a scenario, and for planning purposes, 'inter-city' and 'intra-urban' can be considered one and the same market. Other attributes for the functional specification of a Shanghai - Hangzhou MAGLEV transportation service include:

SPEED: A MAGLEV system is capable of sustained operating speeds of 500 km/hr, which for transport markets up to 500 kilometers is as fast as regional airlines (thus satisfying the proposed 30 minute Shanghai - Hangzhou trip time)

ENVIRONMENTAL SUSTAINABILITY: A URBAN MAGLEV system carrying passengers between Shanghai and Hangzhou would be environmentally sustainable with no emissions.

STATION LOCATIONS: preferred operational characteristic of MAGLEV vehicle systems is the facility to deploy single, double or several self-propelled vehicles on an alignment featuring multiple off-line stations. Conventional High Speed Rail / MAGLEV studies understate this important service attribute, thereby minimizing MAGLEV system ridership and revenue. It is observed that this is not a widely-shared travel attribute as many proposed MAGLEV applications are designed for fixed-consist, downtown-to-downtown service operations.

SERVICE CONVENIENCE: A MAGLEV system must be designed to match several user friendly service attributes from 'intra-urban' transit modes, that is: high frequency, ease of use; ease of access; ease of information provision; ease of ticketing (ideally, no ticketing); ease of passenger processing; and a simplified fare structure.

SECURITY: A MAGLEV system design must be designed to zero-incident tolerances

CONFIDENCE: An 'intra-urban' transportation system (whether highway expressways or public transit) to function effectively must inspire total confidence from the traveling public. Travelers must be assured that when they need to travel, they will always have the transportation system available. In addition to reliability and dependability (for appointment scheduling confidence), a MAGLEV system can be designed to accommodate demand responsive scheduling, by employing Travel Information Systems, an element of Intelligent Transportation Systems (ITS).

COMFORT: In-vehicle and station amenities must be designed to offer a non-hassle, comfortable travel experience for frequent travelers. In contrast to stressful airport transitting or automobile commuting travel for long distances, a Shanghai - Hangzhou MAGLEV system must provide a pleasant, productive travel event.

CAPACITY: The issue of capacity is directly related to the confidence and convenience level of commuters. This is a important question for Shanghai - Hangzhou MAGLEV designers to consider. Excess capacity is an intra-urban travel attribute in which (in economics terminology) an Available Seat Mile is not considered a perishable good. It is, however, a defining attribute for inter-city travel and subjected to yield management. For example, while airlines are not inconvenienced when passengers are asked to wait for the next available flight, its passengers are. While this may be considered a frivolous attribute, consider the likely impact to the urban scale if commuters had only a 90 percent chance of departing for their destination. Fixed capacity restrains urbanization.

COSTS: Although highly influenced by site-specific features and characteristics, local employment rates and costing strategies regarding whether the installation costs are considered sunk costs or are amortized into the fare price, there have been a number of MAGLEV costing studies which can be referenced. The United States National Maglev Initiative Study [3] projected the Revenue Passenger Mile costs for MAGLEV transport to be between USA $0.036 and $0.06 per passenger kilometer in constant 1993 dollars. To recoup operating, capital and financing costs, the fare charge is directly related to the amount of induced demand generated: the greater the demand, the lower the fare; e.g., estimates developed in the *Magneplane* System Concept Definition Report show a range of USA $0.0475 cents per passenger kilometer at 4,000 passengers per hour, to $0.019 at 25,000 per hour [4]

5. URBANIZATION IN THE INFORMATION AGE ECONOMY

In its capacity for change, the new Information Age is being compared to the Industrial Revolution which in addition to transforming the economy, redefined the scale and nature of the urban form. However, this change could not have been accomplished without the combined effect of transportation and telecommunications system advancements that allowed the spatial expansion of the "polis". While the urban form in the last phase of the industrial era (the 'mass consumption / production age) created the modern metropolis, the Information Age form is envisaged to be the Inter-Active Megalopolis, a complex of linked and inter-dependent metropolitan regions.

In the Knowledge-Based Society, the capital value of knowledge has increased substantially and for many corporations often exceeds in value their fixed assets. This changing dynamic portends substantial impacts on the city as it shifts away from one based on the production and circulation of goods to one based more and more on the circulation and consumption of symbolic and informational goods. The effective management of knowledge, that is, the organizational capability to create, acquire, accumulate and exploit knowledge, is increasingly a source of competitive advantage. Global firms source, produce and distribute their products world-wide, continuously striving to minimize their costs and maximize their profits. According to David Clark, *'The organization of the world economy is made possible by, and is maintained through, an international division of labour in which the tasks which people perform, their working conditions and their rates of pay are determined by the requirements of global capitalism'*. [5]

The unprecedented labour mobility represents both a threat and opportunity to the urban form. What does this mean for the future city? What will root the footloose knowledge industry to the physical place? How do planners, financiers and legislators appraise the benefits and costs of future investments in transportation infrastructure that serve industries whose loyalty to the community has declined substantially? This changing dynamic is yet to be understood. However, Michael Porter [6] provides us with a clue when, in 1990, he defined the Technopolis as: *'A geographic concentration of rivals, customers and suppliers will promote efficiencies and specialization. More important, however, is the influence of geographic concentration on improvement and innovation. Suppliers located nearby will be best positioned for regular interchange and cooperation with industry research and development efforts. Sophisticated customers located nearby offer the best possibilities for transmitting information, engaging in regular interchange about emerging needs and technologies and demanding extraordinary service and product performance. Geographic concentration of an industry acts as a strong magnet to attract talented people and other factors to it'*. The implication of this definition is that urban regions that are successful in attracting and maintaining a highly specialized work force in the Information Age, will hold an important advantage in the global competition for knowledge industry. In 1994 Buijs wrote,[7] *'It is the network of cities rather than single, one-centered cities that is the key to understanding today's knowledge-intensive urban economies'*. <u>The thesis of this paper is that the greater the reach and diversity of specialized workers, the stronger the urban competitive advantage. The spatial expression for this new urban form is the "Inter-Active Megalopolis."</u>

At the outset of the Industrial Revolution, Justus Moeser, a German economist,[8] predicted that increased labour specialization would force people to live in larger cities where access to employment and business could be maximized. This trend has continued to this day. Information Age labour requirements and changing demographic patterns are forcing employers and employees to increase accessibility to one another, thus effecting a greater agglomeration of urban economies and employment thresholds. Hans Blumenfeld [9] observed similar changes for the industrial metropolis, that *'The densely crowded agglomeration of the 19th Century with its concomitant fantastic skyrocketing of urban land values, was a short-lived passing phenomenon caused by the time lag between the modernization of inter-city and intra-urban traffic; once this time lag was overcome, it was bound to disappear forever, and few will regret its passing.'*

6. INDUCED DEMAND

Induced demand by new ridership occurs when a totally new transportation system [10] with innovative technology (such as MAGLEV or highways) is introduced into, or superimposed on, an existing urban or regional form. Estimating induced demand requires a normative '2020 Vision' approach. A reality is that North American attempts to project riderships to justify MAGLEV services have been unsuccessful. Rather than promoting MAGLEV to induce ridership (to permit more people to travel further in less time), the North American mind-set has been to evaluate MAGLEV applications on their ability to lessen congestion being experienced by competing inter-city travel modes. Ironically, the prospects then for MAGLEV are tied to the successes of competing transportation systems, that is, greater air travel and automobile demand. In fact, traditional modes and their economic partners view MAGLEV as a competitive threat. This failure of governmental authorities, institutional planners and financiers in Canada and the United States to capture the promise of MAGLEV lies in their lack of recognition of the changing role of inter/intra urban transportation in the Information Age. This oversight is entirely attributed to government policy analysts and transportation planners who decided to isolate (and thus remove from consideration) the millions of daily trips that occur within the boundaries of metropolitan complexes. This decision thus eliminates the possibility that any of these travelers would choose to travel beyond their city boundary to the adjoining metropolis. It eliminates from consideration that MAGLEV speeds will turn 'inter-city' travel into equivalent 'intra-urban' travel, timewise.

The conventional or 'extrapolative' method of Transportation Demand Modeling is based on extrapolating ridership from historical 'inter-city' data and forecasting ridership on the diversionary success of MAGLEV by calculating variables such as trip time, frequency, fare cost, and modal preferences. So for individuals who have never traveled from Hangzhou to Shanghai, it is assumed by conventional modeling that they would not choose to travel from Hangzhou to Shanghai even if the trip time can be reduced to 30 minutes and if the fare cost was very affordable. This approach understates the possibility that in response to reduced travel times and cost, commuters will choose to travel further to access more profitable economic choices and life-style. This classic "Space versus Time" dimension of travel behavior has not been adequately explored.

The conventional planning models cannot replicate the latest transformations of the urban form brought about by the express highways (freeways) or subway systems. Urban history attests to the fact that revolutionary transportation changes effect major structural changes in urban form, namely, the urban form expands in influence. What was formerly considered an 'inter-city' trip prior to the urban transformation was later redefined as an 'intra-urban' trip attributed to the introduction of innovative transportation systems. The experience of the New York subway and North American freeways is testament to this historical fact. According to the Volpe National Transportation Center[11], freeways effected an induced demand rate of 200 percent for average motorists.

Recent Canadian experiences in which totally new transportation system technology was superimposed onto the existing urban form have yielded similar induced demand rates. Within weeks of the opening in July 1997 of the highly computer-controlled Highway 407 around Toronto, Canada, its daily vehicular usage rose by 200 percent to 150,000 whereas modeling had predicted 50,000. Similarly, since the Vancouver fully automated (driverless) linear motor propelled elevated transit system opened in 1986, ridership has risen more than 200 percent over that predicted by traditional planning models. Also, the Skytrain's extension to 30 kilometers has underpinned urbanization of the Vancouver metropolis and facilitated adjoining cities to become dynamic inter-acting economies. The cross-harbour Vancouver Seabus when introduced in the 1970's linking the city of North Vancouver with the Vancouver business core experienced higher than expected ridership levels without observable diversion from other modes.

The authors judge that the ridership demand induced when transportation systems with advanced technology are introduced in newly-modernizing regions could be even higher than the 200 percent over forecasted levels experienced in western post-industrial metropolitan regions. This would certainly be the case where existing transport systems have insufficient capacity, are dated or non-existent. This reality plus the expectations and changes in the next decades due to the Information Age are the basis to project induced demand estimates up to 400 percent.

7. CONCLUSIONS

A concluding recommendation for the designers of the Shanghai - Hangzhou MAGLEV line regarding ridership estimates is to opt for a '2020 Vision' normative approach, that is, what will be the Information Age behaviors which will induce demand for the service in the Year 2020 and beyond. Conventional extrapolative ridership demand models do not handle such a normative approach well or apply it for MAGLEV system planning. The models will invariably predict ridership numbers too low to justify the expenditure in a MAGLEV infrastructure. The authors recommend that an 'induced demand' factor of 200 to 400 percent be applied to conventional models.

8. REFERENCES

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