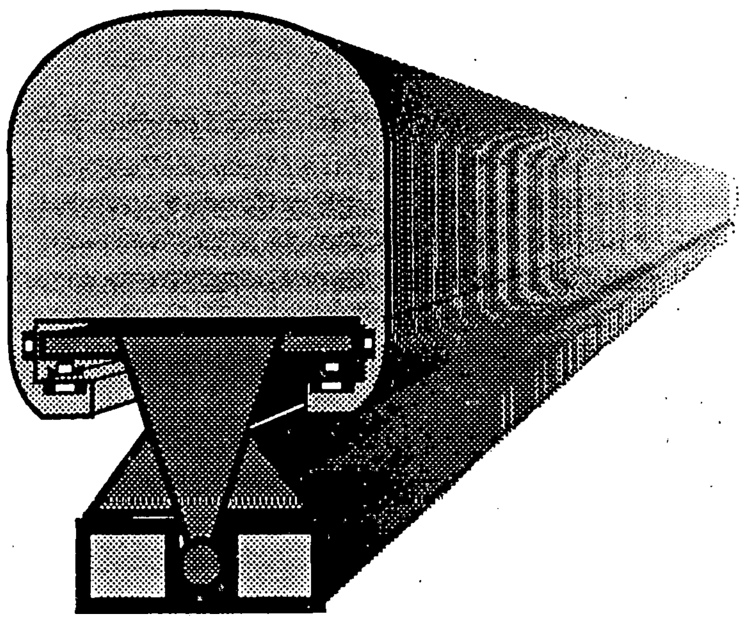
U.S. Department of Transportation
Federal Railroad Administration

Broad Agency Announcement No. 90-1

Office of Research and Development

Magnetic Levitation Transportation System Technology Assessment



U.S. Department of Transportation

U.S. Department of Energy

U.S. Army Corps of Engineers

DOT/FRA/ORD-90/08

September 1990

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PREFACE

Magnetically levitated (maglev) systems represent the latest evolution in high speed ground transportation, offering speeds that can exceed 134 m/s (300 mph) with the potential of low operating and maintenance costs, minimum environmental intrusions and freedom from dependence on petroleum based fuels. In December 1989 an interagency maglev coordinating committee was formed to coordinate maglev efforts within the Federal Government. Membership consists of the Departments of Transportation and Energy and the U.S. Army Corps of Engineers, together with other agencies including the Environmental Protection Agency, the Department of Commerce and the National Aeronautics and Space Administration. This Federal "interagency team" is working together to assess the engineering, economic, and environmental feasibility of maglev in the U.S. and, if appropriate, to stimulate its development by the year 2000. This effort, known as the National Maglev Initiative, will rely heavily on an effective public-private partnership geared toward U.S. industry development of maglev technology.

The National Maglev Initiative consists of the following key activities.

- Assessment of Market Potential, System Economics and Financing
- Assessment and Development of Critical Technologies
- Development of Conceptual U.S. Maglev System Designs
- Assessment of Environment and Health Aspects

This Broad Agency Announcement addresses the second and fourth activity areas above and represents the identification of research interest areas critical to the successful assessment of maglev potential, technological risk and opportunities for technical improvements vis-a-vis existing designs. The Department of Transportation, Federal Railroad Administration, Office of Research and Development is responsible for the planning and implementation of this Broad Agency Announcement (BAA). Research interest areas addressed by this BAA include maglev technologies associated with the vehicle, guideway, control systems and with system level issues such as safety, environment, energy, etc.

Because of the potential for long-term benefits accruing to those firms or institutions involved in these R & D activities, offerors are encouraged to consider sharing the cost of their proposed project.

The provisions of the Competition in Contracting Act of 1984 (P.L. 98-369) as implemented in the Federal Acquisition Regulation provide for the issuance of Broad Agency Announcements as a means of soliciting proposals for basic and applied research. These announcements must be general in nature, identify the areas of research interest, include criteria for selecting proposals and solicit the participation of all offerors capable of satisfying the Government's needs.

The proposals submitted under this Broad Agency Announcement will be subject to technical review. Proposals selected for award are considered to be the result of full and open competition and in full compliance with the Competition in Contracting Act of 1984.

This guide conforms with regulatory requirements of the Federal Acquisition Regulation. It provides prospective offerors information on the preparation of proposals for basic and applied research. Suggestions as to form and procedures are included.

Offerors shall submit a brief proposal abstract not to exceed five pages addressing those areas listed in Part III, Section 4. Proposal abstracts will be responded to within 30 days of receipt, either encouraging submission of a complete proposal or advising the offeror not to submit further details.

Persons contemplating submission of a proposal are encouraged to contact the appropriate Government staff member identified in this publication (Appendix B) to ascertain the extent of interest which the interagency team may have in a specific research project. Not all topics are of equal priority, and the expected funding does not permit efforts to be undertaken in all areas.

Proposals from U.S. Government facilities and organizations <u>will not</u> be considered under this program announcement.

All proposal abstracts and proposals in response to this Broad Agency Announcement shall be submitted to the Office of Procurement, RAD-30; Federal Railroad Administration; 400 Seventh Street, S.W., Room 8222; Washington, D.C. 20590, and should reference this announcement number, BAA-90-1.

<u>FUNDS ARE NOT PRESENTLY AVAILABLE FOR AWARD OF CONTRACTS PURSUANT TO THIS BAA. THE GOVERNMENT'S OBLIGATION UNDER THIS BAA IS CONTINGENT UPON THE AVAILABILITY OF APPROPRIATED FUNDS FROM WHICH PAYMENT FOR CONTRACT SERVICES CAN BE MADE. NO LEGAL LIABILITY ON THE PART OF THE GOVERNMENT FOR PAYMENT MAY ARISE UNTIL FUNDS ARE MADE AVAILABLE TO THE CONTRACTING OFFICER FOR THIS BAA AND UNTIL THE CONTRACTOR RECEIVES NOTICE OF SUCH AVAILABILITY, TO BE CONFIRMED IN WRITING BY THE CONTRACTING OFFICER.</u>

PERSONS SUBMITTING PROPOSALS ARE CAUTIONED THAT ONLY A FEDERAL RAILROAD ADMINISTRATION CONTRACTING OFFICER MAY OBLIGATE THE GOVERNMENT TO ANY AGREEMENT INVOLVING EXPENDITURE OF GOVERNMENT FUNDS UNDER THIS BAA.

The FRA encourages Historically Black Colleges and Universities (HBCUs), Minority Institutions (MIs), small business concerns, and small disadvantaged business concerns to submit research proposals

(HBCUs), Minority Institutions (MIs), small business concerns, and small disadvantaged business concerns to submit research proposals for consideration.

The Bidder/Offeror, by submission of a bid or offer or execution of a contract in response to this solicitation, certifies that the Bidder/Offeror is not debarred, suspended, declared ineligible for award of public contracts, or proposed for debarment pursuant to FAR 9.406-2. If the Bidder/Offeror cannot so certify, or if the status of the Bidder/Offeror changes prior to award, then the Bidder/Offeror must provide detailed information as to its current status.

In accordance with the Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418 Section 5164), it is required that the metric system of measurements be employed to the greatest practical extent in Federal Government procurements. Proposals in response to this BAA shall not be an exception. The International System of Units (SI) is the form of the metric system that is preferred for all applications. In SI there is one and only one unit for each physical quantity: the meter (not centimeter) for length, the second (not minute or hour) for time, the newton (not kilogram) for force, the joule (not kilowatt-hour) for energy, etc. Obsolete metric units are widespread, but should be avoided. For more information consult National Bureau of Standards Special Publication 330, 1986 edition, entitled "The International System of Units (SI)" (GPO order number SN 003-003-02739-1) or American Society for Testing and Materials (ASTM) Publication E380-89a, entitled "Standard Practice for Use of the International System of Units (SI)". If appropriate, the customary units may be added in parenthesis after the SI unit. Customary units (without SI units) may be used in any non-technical language of the proposal. Also it will not be required to revise already existing tables, figures or graphs to be utilized in a proposal, provided that the appropriate conversion factors are indicated thereon.

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PART I

BACKGROUND AND RESEARCH INTERESTS

Background

. National Maglev Initiative

Maglev represents the latest evolution in high speed ground transportation, incorporating sophisticated new designs and technologies. Maglev vehicles glide above their guideway, suspended by frictionless magnetic forces, at speeds that can exceed 134 m/s (300 miles per hour). At such speeds, maglev systems could be competitive in the market for trips of 150 km to 1 Mm (100 to 600 miles) in length and, therefore, able to attract substantial amounts of short haul airway and highway traffic. This could alleviate much of the growing congestion at our airports and on our highways. Initial regional maglev systems could eventually expand and connect to become an inter-regional network and finally, a nationwide network.

Maglev systems offer significant advantages when compared to more traditional transportation technologies. They have the potential of low operating and maintenance costs, minimal environmental intrusions and freedom from dependence on petroleum based fuels. Development of maglev systems may also generate technology spin-offs to other U.S. industries, most notably in the areas of electronics, superconducting materials, magnets, composite materials and construction technologies. Development of a domestic maglev industry could also serve to redirect elements of the American defense-oriented industrial base to a major new peacetime mission.

The Departments of Transportation and Energy and the Army Corps of Engineers are working together with a common purpose to develop a public-private partnership that will help answer the question of the appropriate role of maglev in our nation's transportation future. This effort, which we call the National Maglev Initiative, will assess the engineering, economic and environmental aspects of maglev, determine its feasibility and appropriate place in the American transportation system and stimulate the development of a U.S. maglev system suitable for commercial application in this country by the year 2000. Successful development and implementation of an American maglev system will require substantial participation by the private sector. One of the most important tasks of the National Maglev Initiative is the development of an effective public-private partnership geared towards eventual implementation of U.S. made maglev transportation systems.

. Maglev Development Program

Recommendations in 1992 on whether to pursue future development of maglev will be based on the results of a number of technical and economic assessment and development activities. This schedule dictates that significant conclusions be forthcoming from the work addressed here by March of 1992. During FY 1991 and FY 1992, the National Maglev Initiative will focus on following key areas: a) assessment of market potential and system economics; b) assessment and development of critical technologies; c) development of maglev systems concept designs; and d) assessment of environmental and health aspects. This Broad Agency Announcement (BAA) addresses both the areas of critical technologies and environmental/health aspects above. The research activity to be performed under this BAA will address technology/environmental questions/issues both at the subsystem/component level as well as at the system level and will identify/evaluate areas that are critical to successful development of a maglev system. The information developed under this BAA will be shared with the participants in the maglev systems concept design activity (awarded under separate procurement action) through conferences and through the exchange of draft and final reports.

Research Interests

The research activity to be performed under this Broad Agency Announcement has the following objectives:

- To establish baseline information on the state of the art of maglev-related technologies necessary to evaluate alternative systems concept designs
- To identify the technology areas and their inherent risks that are critical to the development of an advanced maglev system and to perform the immediate research necessary to mitigate or resolve the risk issues
- To define research for reducing the cost of the maglev system infrastructure
- To provide engineering data on the characteristics of maglev subsystems and components in order to quantitatively compare cost vs. performance data
- To stimulate and support the interest of U.S. industry, universities and research organizations in participating in the advancement of maglev technologies
- To provide for the input of creative approaches and innovative maglev technology concepts from individuals and small firms

This activity will generate a series of technical evaluations and analyses, trade-off studies and risk assessments, as well as a variety of creative ideas and innovative approaches. Also, this activity will assess the environmental and health effects of maglev systems, determine their relative significance and recommended design features to minimize or eliminate any potentially adverse impacts.

Research will be conducted to enhance the knowledge base or advance the state of the art in the following:

- Areas known to have technical risks, which could adversely affect cost, performance, or impact the public
- Areas where opportunities exist for significant improvement over existing systems
- Areas of critical importance to system performance and safety
- Areas where additional knowledge and data are necessary as a basis for Government and industry/user evaluation of systems concept designs (for reference, see Appendix A, Maglev System Parameters)

Investigation areas under this BAA are categorized as follows:

- Vehicle systems
- Guideway systems
- Control systems
- Systemwide considerations

VEHICLE SYSTEMS (1.0)

SUSPENSION (LEVITATION) SYSTEMS (1.1.0)

Primary Suspension (1.1.1)

The function of the primary suspension is to support and guide the vehicle along its route. These forces may be actively or passively controlled.

Technical data and information required in this area for both the electromagnetic (EMS) and electrodynamic (EDS) levitation systems include:

a. Definition of load requirements including wind effect

b. Tradeoffs between clustered and concentrated vehicle magnets (taking into account the possible benefits of high temperature superconductors)

c. Magnet system force-weight-gap-power-speed characteristics achievable with current technology

d. Response characteristics of magnet system to guideway irregularities

e. Potential improvements in these characteristics (achievable by application of new scientific data in the fields of magnetism and superconductivity)

f. Magnet system configurations and control systems to assure positive guidance and control of vehicle position relative to guideway while minimizing detrimental magnetic field effects (taking into account the possible benefits of high temperature superconductors)

g. Design of magnet control systems to force the vehicle to follow a less than perfect guideway while accommodating ride comfort goals

h. Estimates of primary suspension characteristics and control systems algorithms for existing maglev vehicle systems

i. Magnet suspension system failure modes and effects

j. Estimate of electrical power requirements for magnetic levitation and guidance as a function of vehicle speed

Secondary Suspension (1.1.2)

The function of the secondary suspension is to provide acceptable vibration isolation for the passenger compartment to assure ride comfort. In the electromagnetic system, the magnets typically follow the guideway irregularities while maintaining a small, near constant gap. Separate suspension elements are typically used between the magnet support and guidance elements and the passenger compartment. In the electrodynamic system, it may be possible to use the primary system to perform both the primary and secondary suspension functions. These functions may also be passive or actively controlled.

For both electromagnetic and electrodynamic systems, the following information is required:

a. Dynamic response of vehicle body to guideway irregularities

b. Response to steady and transient aerodynamic loads for existing maglev systems

c. Reduction in ride vibration achievable with passive suspension systems

d. Reduction in ride vibration achievable with active suspension systems, and associated power penalty

e. Techniques for control of primary suspension forces to assure ride vibration comfort, together with weight and power required

Superconducting Magnets (1.1.3)

The electrodynamic maglev system relies on superconductors to generate the high intensity magnetic fields necessary for levitation. Present systems operate at the cryogenic temperatures of liquid helium (4.2 K), but will be significantly enhanced when practical high temperature superconductors become available. There exist many research initiatives and opportunities for technological breakthrough in this area, among them are:

a. Assessment of relative system costs of low temperature versus high temperature superconductivity and high temperature superconductor research and development to determine whether it is likely to become available for maglev application in time

b. Research on application of high temperature superconductor materials to maglev

c. Improvement in efficiency of cryogenic systems for control of low temperature superconducting magnet levitation

d. Investigation of quench detection and prevention in superconducting systems

e. Superconductor redundancy and impact of quench on co-located magnets

f. Provision for planned obsolescence of low temperature superconducting magnet suspension and replacement with high temperature superconducting counterpart

Suspension Control Systems (1.1.4)

Passive maglev vehicles require that propulsion be controlled from the wayside, however, reliable levitation/guidance gap sensors and controls must be located on board the vehicle. Because the reliability of these systems will be safety critical, "fail-safe" improvements must be sought.

POWER, PROPULSION AND BRAKING SYSTEMS (1.2.0)

The power, propulsion and braking systems include the higher level electronics systems which are the sources of vehicle auxiliary power, vehicle motion and braking. Power distribution and control will also be important considerations in conducting economic analyses and in developing optimum power system configurations for maglev systems.

Technical data required in this area for both the electromagnetic and electrodynamic levitation systems includes:

Power (1.2.1)

a. Estimates and measurement of power consumption for propulsion, levitation, guidance and braking.

b. Estimates and measurement of power factor and efficiency

c. Pulsed power needs, influence of transients, periodicity and harmonics

d. Requirements for system optimization, e.g., in distribution losses vs. substation spacing, voltage/current ratings of wayside equipment, etc.

e. Techniques and performance of systems for providing power to on board systems (communications, cooling, heating, ventilation, and air conditioning, other electrical systems, i.e. "hotel power")

f. High speed power collection--inductive vs. contacting transfer

g. Suspension and guidance control systems power requirements in turnouts on exit and entry from mainline

Propulsion (1.2.2)

a. Propulsion power requirements as a function of speed, acceleration, and braking capabilities (see also "Power" above this heading)

b. Relationships among physical dimensions, current, voltage, power factor, normal force, thrust, vehicle speed and gap for existing linear motor designs

c. Potential for improvements in linear motor performance through application of improved technology, e.g., reluctance motors, synchronous motors, induction motors, long vs. short stator, etc.

Braking (1.2.3)

a. Performance of various braking techniques including aerodynamic, electrodynamic, and friction

b. Definition of service braking vs. emergency braking requirements

c. Safety implications of primary brake systems that rely on the propulsion system

d. Options for "fail-safe" backup brake systems not related to the primary brake/propulsion system

VEHICLE CONFIGURATION AND STRUCTURE (1.3.0)

Aerodynamic Forces and Moments (1.3.1)

a. Performance requirements when opposing vehicles pass on adjacent guideways at cruise speeds, including entering, transiting or leaving tunnels

b. The influence of structures adjacent to the guideway on a high speed maglev vehicle

c. Acoustic noise generation and configuration characteristics to be avoided; use of deflectors

d. Energy usage implications of speed vs. competing modes

e. Aerodynamic energy tradeoffs through enhanced design (such as lift through winged configuration), vehicle/guideway shape parameters (as in boundary layer control and its effect)

Single or Coupled Vehicle Operation (1.3.2)

a. Vehicle dynamics and structural implications of separate vs coupled vehicles, shared bogies, and length of consist

b. Mechanics of coupling

c. Multi-vehicle effects on system design

d. Implications of multiple sets vs. single vehicle shared auxiliary systems on overall reliability vs. its use to obtain redundancy

e. Payload considerations in single vs. coupled vehicles

Collision Loadings (1.3.3)

a. Resistance vs. attenuation of forces--rail vs. air philosophies

b. Definition of requirements to achieve minimization of low speed collision impact on passengers and operator

GUIDEWAY SYSTEMS (2.0)

The guideway system includes the complete supporting structure consisting of: the foundation, superstructure, and the guideway itself- along with any propulsive elements incorporated into the guideway. In addition to its functions of support and guidance, the guideway may also play an active part in the propulsion and braking of the vehicle.

Since a large percentage of the capital costs of a maglev system is in the guideway system, innovative guideway configurations which minimize guideway life cycle (capital and maintenance) costs are essential. The study topics listed below are primarily oriented toward the achievement of this objective, consistent with operational and safety requirements.

Guideway Structural Design (2.1)

a. Relationships between guideway construction costs, reaction rail/surface dimensional irregularities, span deflections, span lengths and single vs. linked vehicle loads

b. Innovative guideway configurations which minimize guideway life-cycle (capital and maintenance) costs

c. Guideway structure designs which are perhaps more massive and complex than minimally required, but which support multiple uses (such as fiber-optic and power transmission lines and both low and high speed maglev), thereby providing better overall economic benefits to the system as a whole. Study area includes investigation of alternative use of air space over/under the guideway

d. Innovative guideway materials which reduce life-cycle costs (whose development would be consistent with timely system implementation and code compliance), including items such as innovative surface coatings and composite (non-metallic) materials

e. Innovative fabrication techniques, especially those suited to mass production and modularization, which reduce capital costs and promote more accurate guideway alignment during the construction process

f. Existing guideway structural configurations: performance and costs. Study to include analysis and comparison of physical characteristics, means of adjustment to correct geometric deviations, and fabrication methods

g. Guideway dynamic behavior, with emphasis on harmonic oscillation damping

h. Structural design requirements for resistance to extreme forces, such as high winds and earthquakes

i. Structural requirements to anchor and support existing designs of propulsion and levitation equipment

j. Innovative foundation designs which reduce capital costs and enhance long term guideway stability

k. Methods to improve tunneling and earthwork cost estimates

l. More cost-effective soil survey techniques

m. Dynamic response and material properties of foundation soils

n. Dynamics of maglev guideway systems

o. Guideway diagnostics: techniques which will allow the guideway to self-monitor its geometric alignment and physical condition, including the presence of debris, snow and ice

p. Cost/benefit analysis of elevated, near grade, and underground guideways, including issues relating to safety, operational capabilities, right-of-way acquisition, and levels of service amenities permitted by each

q. Cost/benefit analysis of using fully enclosed guideways or evacuated tubes as guideways, including issues of safety, operational power requirements, and protection from weather. Also of interest are methods to enclose open guideways as part of a future modification (where desirable), and how this ability could be allowed for in the initial guideway design

r. Cost and performance analysis of methods to attach propulsion and levitation equipment to guideway, including integral fabrication techniques

s. Methods to maintain guideway alignment within allowable tolerances, in response to foundation settling, frost heave, minor seismic forces, thermal stresses, and wind loads

t. Effect of thermal stresses, especially for continuous sheet guideways

u. A study of the importance of magnetically inert materials: the need for them and cost/benefit implication

v. Effects of adverse weather conditions on guideway performance and durability, and methods to reduce these effects. Study to include potential effects of snow, ice, lightning, large temperature fluctuations, rain, and storms

Power/Propulsion/Braking in Relation to Guideway (2.2)

a. Cost, performance characteristics, and fabrication techniques for existing maglev propulsion and braking systems, in relation to guideway fabrication

b. Cost, performance characteristics, and fabrication techniques for linear electromagnetic motors suitable for maglev, in relation to guideway fabrication

c. Optimum sizing and spacing of propulsive elements and related power supply equipment, in relation to guideway fabrication

d. Power distribution requirements vs. speed, acceleration, grade, curvature, relative wind (head), vehicle/train size, duty cycle

e. Innovative methods to minimize life-cycle (capital and maintenance) costs of power and propulsion equipment, including preventive maintenance policies

f. Dynamic loads on guideway induced by propulsion and braking systems, in relation to guideway fastening and maintenance requirements, including unique methods of fastening propulsive elements to the guideway

g. Performance characteristics and cost of emergency braking systems

h. Vehicle speed and position control equipment, as it affects guideway design and maintenance

i. Failure modes and backup measures for power, propulsion, and braking systems, in relation to guideway design

Route Divergence (Turnouts) (2.3)

a. Switching characteristics most desirable from a system viewpoint, and suggestions for their implementation, including safety, fail-safe operation, geometric design, and ride comfort issues

b. Turnout designs which require no physical movement of the guideway components - relying on magnetic forces to control guidance along either route. Study to include design costs and benefits and safety issues

c. Innovative approaches, including vertical entry and exit designs and moving passenger transfers: costs, benefits, safety and other operating issues

d. Turnout materials and maintenance requirements for different designs

e. Cost and performance characteristics of existing and proposed turnout designs, including safety, ride comfort, and other system operating issues

f. Sensor and software requirements to assure safe operation through turnouts

Route Alignment and Right-of-Way Issues in Relation to Guideway (2.4)

a. Maximum grade, curvature, bank angle, and their rates of change which can be tolerated while maintaining safety and passenger comfort, as influenced by operational speed

b. Suitability of existing highway and railroad rights-of-way to accommodate a maglev guideway, including concepts for taking the most effective advantage of these potential right-of-way resources

c. Cost benefit analysis of using existing rights-of-way compared with constructing guideways on all new routes

d. Definition of span length limiting factors for existing guideway configurations

e. Effect of guideway structure, the construction process, and maglev operations on activities adjacent to guideway and right-of-way, including safety issues, noise, vibration, visual effects, and removal of snow and debris from guideway

CONTROL SYSTEMS (3.0)

These systems include those elements of a maglev technology that ensure a guideway system is safe for operation (route integrity) and that the vehicles and guideway are, in fact, operated within authorized limits (safe speed and headway enforcement).

Route Integrity (3.1)

Since maglev systems are obliged to operate within fixed envelopes the requirement to ensure the path to be taken by each and every vehicle is safe is not unlike the similar requirement for conventional wheel on rail train systems except, perhaps, for rate of closure issues. However, some additional elements that may be unique for maglev systems and thus require additional technical investigation and data in this area include:

a. Communication options between the vehicle, guideway and central control. The requirements of these sometimes "vital" links must be part of the investigation of the various options.

b. Look ahead capabilities for high speed operation 134 m/s (300 mph) to include detection of objects fouling the operational envelope but not necessarily touching the guideway.

c. Guideway integrity sensors for vertical or horizontal misalignment of the guideway during vehicle/train operations

d. Physical security issues and their tradeoffs

e. Options for other hazard identification systems

Safe Speed Enforcement (3.2)

Again, these control systems will not be unlike similar systems used on certain automated train systems in the U.S. such as San Francisco's BART, Washington's MetroRail, or Amtrak on the Northeast Corridor. However, unique differences exist for maglev systems that require additional technical investigation and data in this area include:

a. "Fail-safe" options for position, speed, and location sensing (or determination) that are compatible with the technology. Position location of vehicles in the system cannot be track circuit based (shunted by vehicle contact) since maglev is a "non-contact" system

b. Totally automated operation versus supervised manual operations and override options and the human factors implications of these alternatives

c. Options for emergency or backup control

Software and Hardware Verification (3.3)

Automated control systems, as used in existing maglev system configurations and anticipated for use in future maglev transportation systems, require verification of vital hardware and software systems. Sophisticated hardware and software will likely be used, and thus a critical analysis of these systems is essential.

Technical data required in this area include:

a. Development of requirements for acceptable failure mode analysis and fault tree characterizations of a control system design

b. Definition of vital system elements requiring "fail-safe", "fail-tolerant" or "safe life" treatment

c. Establishment of reliability determination criteria and methodology for determining accurate mean time between failure (MTBF) estimates for the multi-tiered, autonomous and redundant control systems

SYSTEMWIDE CONSIDERATIONS (4.0)

Emphasis in the system consideration area is on the performance of the system as a whole, as measured in parameters judged to be of primary importance, toward the system goal of providing a competitive, alternative mode of surface travel for the 21st Century. It is inherent in the "System" concept that there be coherence internally within the system as well as balanced compatibility with the external environment.

Electromagnetic Fields (4.1)

The subject of electrostatic and electromagnetic field level exposure limits for humans is becoming a concern of the public, environmentalists and medical professionals. These concerns must be addressed and safe field intensity limits established. To assist in assessing the potential hazards and development of or compliance with acceptable human exposure levels, the following technical data are required:

a. Determination by measurement and analysis of magnetic field strength, spatial and temporal distribution (with attention to recently discovered critical windowing effects) from EDS and EMS maglev vehicles and/or their associated wayside magnetic circuits (underway)

b. Compilation of existing data on known hazards of magnetic fields upon humans (underway)

c. Comparison of maglev system produced magnetic fields to those normally found in everyday surroundings at work and at play (underway)

d. Interim recommendations as to acceptable levels of exposure (underway)

e. Techniques for obtaining real time measurement of critical field values and personal cumulative exposure levels (this BAA)

f. Techniques for control of excessive leakage magnetic fields, including active shielding, advanced magnet design, HTSC thin films and lightweight ferromagnetic shielding

Tasks (a) through (d) above are already underway and are shown for reference only (not for proposal).

Electromagnetic Interference/Electromagnetic Compatibility (4.2)

In the past, introduction of new power conditioning systems into the ground transportation environment has led to safety problems caused by low (less than 10 kHz) frequency interference with vehicle control and signaling systems. Wayside enterprises have also expressed concern that a new system will cause malfunction of their electronic systems because of high frequency radiations emanating from vehicles, power supplies and power distribution systems. Potential problems can be eliminated by performing an electromagnetic radiation assessment of proposed systems.

Technical data required in this area for both the electromagnetic and electrodynamic levitation systems include:

a. Susceptibility of typical near maglev right of way equipment

b. Determination of vehicle and guideway transmitted electromagnetic radiation

c. Susceptibility of vehicle and guideway systems to external electromagnetic fields (e.g., as from parallel and adjacent high voltage power lines or transients caused by solar magnetic storms and large flares)

d. Determination of ambient electromagnetic environment along potential maglev corridors

e. Definition of suitable countermeasures to electromagnetic interference

f. Susceptibility to lightning strikes and the electric fields generated by them

Environment (4.3)

A maglev transportation system will present a new impact on the existing environment where it is installed. Likewise, the system can be expected to have to cope with the environment where the market exists. Therefore, efforts must be undertaken to determine these impacts and the most effective means to mitigate any undesirable attributes.

Technical data required in this area for both the electromagnetic and electrodynamic levitation systems include:

a. Definition of the system's likely surrounding environment and its probable impact on system performance

b. Definition of the system's impact on its surrounding environment including wildlife, ecosystems and land use

c. Aerodynamic noise studies and predictions coupled with development to reduce that noise by active and passive suppression techniques (see also "Aerodynamic Forces and Moments")

d. Risk-reward tradeoff vs. automobile, airplane emissions and cosmic ray exposure at altitude when in airplane

e. Definition of system sensitivity to climatic conditions

Vehicle-Guideway Interface (4.4)

The vehicle-guideway interface of a maglev transportation system is highly dependent on the many unique system factors inherent to the technological approach involved, i.e., electrodynamic or electromagnetic. Guideway geometry together with the vehicle suspension system determines the passenger ride quality and the dynamic forces on the structures involved. Analysis of the dynamic interaction between a maglev vehicle and its guideway is necessary from both safety and performance considerations and is a key factor in defining requirements for vehicle suspension, guideway tolerances and ride comfort. Technical information and data are required in the following areas:

a. Tradeoff analyses between primary suspension characteristics and secondary suspension requirements

b. The tradeoffs among ride comfort, guideway construction and maintenance tolerances, pier separations, beam stiffness, linked vs. unlinked vehicles and associated guideway costs

Test Facilities (4.5)

New maglev technology requires for its deveopment a coordinated research test program. At the various stages of development appropriate test requirements will exist.

Technical data required for both electromagnetic and electrodynamic levitation systems may necessitate the development and construction of three levels of test facilities including:

a. In the earliest stage of technology assessment, laboratory scale experimentation devices may need to be used to verify various analytical findings or to establish a data base.

b. During the early exploratory research stage, the use of scale or full-sized vehicle model and test guideway configurations may be needed to confirm preliminary systems concept designs prior to making the significant investment required by a full-sized test facility.

c. In the preprototype and prototype stage of development and even during a system's operational life-cycle, a full-scale test facility may be required to insure system functions are in accord with earlier design determinations and the expected response is achieved in accordance with the performance parameters of an operational requirement.

Planning for these tests and the required facilities is sought.

Human Factors (4.6)

Maglev will be an automated system, so it is necessary to look at the "man/machine" interface and determine to what extent functions and procedures should be automated. Technical information on human factor considerations associated with high speed maglev transportation systems include:

a. Passenger interface with the system and compliance with Americans with Disabilities Act of 1990
b. On-board operator and attendant interfaces with the system

c. System operations and maintenance personnel interface with the system.

Additionally, technical information should be obtained on the reaction of automobile drivers to high speed maglev systems that utilize highway rights-of-way or cross them, and methods for minimizing such reactions as the "startle effect", if significant.

Safety and Emergency Procedures (4.7)

With respect to existing safety regulations, it is not clear whether maglev should be regarded as a form of air transportation or a form of rail transportation. The combination of high speed capability and the unique non-contacting suspension characteristics may not allow direct applications of existing regulations and/or safety designs and practices. Technical information and data are required with respect to:

a. Vehicle crashworthiness and the implications of attempting to apply existing air and rail system safety standards

b. Emergency procedures (vehicle evacuation and movement of evacuees along or off guideway to a safe haven, enhanced emergency braking/stopping, expedited movement of dead vehicle off line, safe operation of the remainder of the system during an emergency)

c. Accommodation of suspension or propulsion system failure at high speed

d. Fail-safe switching

e. Rain, lightning, flood, windstorm, and earthquake protection

f. Provision for manual override of automatic control systems by operator or central control

g. Impact on any or all components of the system caused by a local or general power failure

h. Maintenance of a safe cabin environment during emergency situations

i. Strategies for efficient and safe resumption of service following the clearing of an emergency situation

Intermodality (4.8)

As maglev will be a part of an overall transportation system, intermodality must be assured. Optimizing of the interfaces between maglev and other transportation modes (automobile, bus, train, plane) is necessary to assure total trip times between origin and destination that are attractive to the traveler. Issues to be addressed are

a. Creative approaches to integrating maglev with other transportation modes, including the overcoming of technical, institutional and economic barriers thereto

b. Dual use, including merging and diverging, of guideways with other modes, particularly in the vicinity of terminals

INNOVATIVE CONCEPTS (5.0)

This topic refers to ideas for dramatically reducing the cost or improving the efficiency or performance of a maglev transportation system through the use of novel components, system layout or operational strategies. This is not to be confused with the overall system concept design, which is the subject of a subsequent procurement. An example would be a new way of transferring propulsion power from the guideway to the vehicle so as to be less costly than the long stator linear electric motor. The intention here is to support the analytical and experimental research needed to take a meritorious concept to the stage where its systemwide implications can be assessed and a scientific choice can be made between it and existing technology. Whatever this may require should be made evident by the proposer.

PART II

REVIEW OF PROPOSAL ABSTRACTS AND EVALUATION OF PROPOSALS

A. Upon receipt of a proposal abstract (not to exceed 5 pages), the interagency team will perform an initial review of its scientific merit and potential contribution to the program objectives and also determine if funds are expected to be available for the effort. Offerors of abstracts of interest will be encouraged to submit a full proposal (in the format outlined in Part III) and these proposals will be evaluated in accordance with the criteria in paragraph B.

B. Proposals submitted in response to this BAA will be evaluated as received, using the following factors:

1. The overall scientific and/or technical merits of the proposal

2. The potential contributions of the effort to the National Maglev Initiative mission specifically including U.S. competitiveness and the extent to which the research effort will contribute to balancing the overall maglev contract research program

3. The offeror's capabilities, related experience, facilities, techniques, or unique combinations of these which are integral factors for achieving the proposal objectives

4. The qualifications, capabilities, and experience of the proposed principal investigator, team leader, and other key personnel who are critical to achievement of the proposal objectives

5. The reasonableness and realism of proposed costs and fee (if any), and the extent of cost sharing

6. The availability of funds.

C. Proposal abstracts and proposals not considered to have sufficient scientific merit or relevance to U.S. maglev development needs or those in areas for which funds are not expected to be available may be declined without further review.

D. Offerors will have 30 DAYS from the date of the letter notifying them of the results of the evaluation of their proposal abstracts to deliver full proposals to the address shown in PART III, Section 2.

PART III

PROPOSAL ABSTRACT AND PROPOSAL PREPARATION

SECTION 1 - INTRODUCTION

This part is intended to provide information needed in preparing research proposals for submission to the FRA.

In order to avoid unwarranted effort on the part of the offerors and the Government evaluation team, potential offerors must first submit a proposal abstract which must be delivered to the addressed shown in Section 2, below.

Offerors intending to address more than one topic shall do so by submitting one abstract per topic. Each abstract shall be limited to not more than five (5) pages.

Organizations or individuals interested in submitting research proposals to the FRA are encouraged to make preliminary inquiries to staff scientist/engineer contact shown in Appendix B as to the general need for the type of research effort contemplated before expending extensive effort in preparing a detailed research proposal or submitting proprietary information. The research proposal often represents a substantial investment of time and effort by the offeror, and it should present the proposed research effort in sufficient detail to allow the FRA to evaluate the scientific merit and relevance of the proposed research.

Inquiries concerning administrative and/or contracting information may be obtained from the Federal Railroad Administration, Office of Procurement, Attn: Daniel O'Brien (202) 366-0558 or Robert Spratling (202) 366-0571.

SECTION 2 - GENERAL INFORMATION

DEFINITIONS:

A. Small Business Concern. A concern that is independently owned and operated, is not dominant in the field of operation in which it is bidding on Government contracts, and with its affiliates employs not more than 500 employees. The Standard Industrial Classification (SIC) code for this acquisition is 8731.

B. Small Disadvantaged Business Concern. A small business concern which is at least 51 per centum owned by one or more socially and economically disadvantaged individuals; or, in the case of any publicly owned business, at least 51 per centum of the stock of which is owned by one or more socially and economically disadvantaged individuals and whose management and daily business operations are controlled by one or more of such individuals.

PROPOSAL PREPARATION AND SUBMISSION:

In preparing proposal abstracts and proposals it is important that the offeror keep in mind the characteristics of a suitable proposal acceptable for formal evaluation. It should include all the information specified in this announcement in order to avoid delays in evaluation. Proposal abstracts and proposals must reference the code number for the specific research area (shown at the end of area and sub-area titles).

Proposal abstracts and proposals shall be delivered to:

Office of Procurement, RAD-30
Federal Railroad Administration
400 Seventh street, S.W., Room 8222
Washington, D.C. 20590

Abstracts may be delivered by telefax using FAX number (202) 366-3055 not later than October 5, 1990. Any telefaxed submission should be followed by five (5) copies of each abstract postmarked not later than October 5, 1990.

Offerors intending to address more than one topic shall do so by submitting one abstract per topic. Each abstract shall be limited to not more than five (5) pages.

NOTE: While proposal abstracts may be submitted by telefax as described above, full proposals will not be accepted by telefax.

A full proposal must be delivered to the address shown above within 30 DAYS from the date of the letter notifying the offeror of the results of the evaluation of the abstract.

SECTION 3 - TYPE OF CONTRACT

Selection of the type of contract is based upon various factors, such as the type of research to be performed, the contractor's experience in maintaining cost records, and the ability to break out and allocate proposed costs and performance of the work.

A document commonly used because of its flexibility in supporting research, is a cost reimbursement or cost sharing type contract. This type of contract permits reimbursement for all or a portion of the actual costs incurred in the accomplishment of research. It also permits some flexibility in the redirection of efforts due to recent research experiment results or changes in Government guidance.

Fixed price contracts are used when the research projects costs can be estimated accurately, the services to be rendered are reasonably definite, and the amount of contractor furnished property, if any, is fixed.

Contracts awarded by the FRA will contain, where appropriate, detailed special provisions concerning patent rights, rights in technical data and computer software, reporting requirements, equal employment opportunity, etc.

Report Requirements: The number and types of reports will be specified in the contractual document. The reports will be prepared and submitted accordance with FRA report procedures which will be provided the awardees.

SECTION 4 - CONTENT OF PROPOSAL ABSTRACTS

Proposal abstracts shall be limited to not more than five (5) pages. Five copies are requested. The proposal abstract should reference BAA-90-1 and shall contain the following:

1. A title descriptive of the research to be performed; include the numerical code for the specific research area shown herein at the end of the area and sub-area titles (e.g., "1.1.1" for Primary Suspension)

2. The name and address of the individual, company or educational institution submitting the abstract and a brief description of relevant corporate or institutional experience

3. The name and phone number of the principal investigator or senior researcher in charge of the project

4. The proposed duration of the project (not more than 18 months)

5. The estimated total cost broken down into its component parts, including labor cost, materials cost, burden, and profit (if any)

6. One or more paragraphs describing the objective(s) of the proposed research to include a statement of the working hypothesis to be proved or disproved, if appropriate

7. One or more paragraphs describing the approach to be taken in the course of the research; if experimental, it should include a description of the scope of the testing program; if analytical it should include key assumptions to be made, the scientific basis for the analysis, and the numerical procedures to be used; and if a combination of these, it should be broken into two phases, i.e., analytical and experimental

8. One or more paragraphs describing the potential technological spinoffs or payoffs that might ultimately derive from the proposed research to the overall maglev program

9. A one-page curriculum vitae of the principal investigator

SECTION 5 - CONTENT OF PROPOSALS

Proposals shall be furnished in five (5) copies and contain the following:

TECHNICAL

The technical portion of the proposal shall be limited to not more than seventy-five (75) pages and shall contain the following:

1. A complete discussion stating the background and objectives of the proposed work, the approach(es) to be considered, the proposed level of effort, and the anticipated results/products

2. The names, brief biographical information, experience, and a list of recent publications of the offeror's key personnel who will be involved in the research

3. The names of other agencies to whom the proposal has also been submitted, if any

4. A brief description of offeror's organization

5. Schedule including milestones as appropriate

COST

The cost portion of the proposal shall contain a cost estimate for the proposed effort sufficiently detailed by element of cost for meaningful evaluation. The estimate shall be summarized on a SF-1411 form (a copy of which is supplied herewith) and broken down for each year of the proposed work and shall include the following:

1. A complete breakdown of direct of labor to include, by discipline or individual, hours or percentage of time and salary

2. Fringe benefits rate and base

3. An itemized list of equipment showing cost of each item

4. Description and cost of expendable supplies

5. Complete breakdown of travel to include air and rail fares, per diem, rental car, etc.

6. Complete breakdown of any subcontracts

7. Other direct costs (reproduction, computer, etc.)

8. Indirect cost rates and bases with an indication whether rates are fixed or provisional and the time frame to which they are applied

9. Proposed profit or fee, if any, and the extent of cost sharing

In addition, offerors shall furnish the name and telephone number of the cognizant audit agency if they have been audited.

OTHER INFORMATION

To aid in the preparation of contracts for those proposals selected for award, an offeror should furnish, in the block with its name and address, the following information: its Data Universal Numbering System (DUNS) number; its Commercial and Government Entity (CAGE) Code; and, its Tax Identification Number (TIN).

APPENDIX A -- MAGLEV SYSTEM PARAMETERS

The following draft of maglev system parameters should not be regarded as hard and fast requirements. These parameters have and will continue to evolve as more is learned about the tradeoffs among them.

MAGLEV SYSTEM PARAMETERS

August, 1990

The following draft system parameters have been prepared by a Federal interagency working group and are intended to become the framework for procurement or agreement documents for the development of conceptual system designs. Those parameters preceded by MR (minimum requirements) are performance specifications which a proposed system must meet to be acceptable. Those which are preceded by DG (design goals) are target performance levels and will not be essential conditions of acceptability for proposed systems. *Italicized material reflects changes which were made to the previous draft as a result of comments received at the Technical Workshop in Argonne, IL on July 11-13, 1990.*

1.0 System Requirements

(a) Speed - (DG) Cruising speed of 300 mph or more. The cruising speed for a particular system is the result of tradeoffs of route alignment, power supply capacity, passenger throughput, along with other parameters. The Maglev system speed should be sufficient to allow total trip times equal to or better than those achieved by current commercial air systems.

(b) Capacity - (DG) Capacity should be in the range of 4,000 to 12,000 seats per hour in each direction. The lower figure would be appropriate with a guideway of low cost. The higher figure would appear to be required to serve the very highest volume markets, possibly at some sacrifice in terms of capital cost.

(c) Ride Comfort - (DG) *The system shall provide a level of ride comfort equivalent to computed levels using the "composite" method described in "Development of Techniques and Data For Evaluating Ride Quality, Vol. II, Feb., 1978, Report #DOT-TSC-RSPD-77-1, II, R.D. Pepler et al." The composite method is derived from analysis of both airplane and ground system environments and considers linear accelerations of the vehicle (primarily transverse and vertical), angular rotation of the vehicle (primarily roll rate) and the acoustic noise levels. Appendix A provides additional detail.*

(d) Noise and Vibration - (DG) *The noise and vibration produced by total system operation should be designed to meet existing Federal standards and industry practices, as appropriate, for stationary facilities such as maintenance areas and stations. Noise and vibration produced by the vehicle traversing the guideway should be minimized. Potential noise and vibration im-*

pacts and possible mitigation methods in urban areas should be given special attention. The Code of Federal Regulations, Title 40, Chapter I, Part 201, Noise Emission Standards for Transportation Equipment; Interstate Rail Carriers should be used for guidance but caution must be used in extrapolating such information to high speed operations at or near grade.

(e) Magnetic Fields - (DG) *Human* exposure to *AC and DC* magnetic fields shall be minimized.

(f) Weather - (DG) Operation compatible with all common U.S. weather conditions (e.g., wind, snow, rain, fog, icing, heat, lightning, etc.) with minimal degradation in system performance. In the region of operation, maglev should be the transportation mode least affected by adverse weather conditions.

(g) Controls - (MR) All controls must be fully automated and fail-safe. (DG) A central facility will operate the system, receiving and integrating data regarding the status and integrity of all vehicles and guideways, the locations of all vehicles, guideway power requirements, vehicle routing requests, etc. (MR) The system control software must also be fail-safe, equivalent to the level of reliability defined by the Federal Aviation Administration (FAA) for flight control software for military and civilian aircraft. See Federal Aviation Regulation 25.1309, Amendment 25-23 and Advisory Circular 25.1309-1. Copies of the referenced material will be made available, upon request, to the offerors.

(h) Safety - (MR) A system safety plan must be included which discusses possible failure modes, *human operation considerations*, evacuation procedures, system restart, equipment and software *availability*, safety inspections, consequences of vandalism and trespassing, etc. The central control facility will log all operations and communications for subsequent analysis in the event of a failure. Consideration must be given to safe use of materials and construction methods, and to the safety of other users of the rights-of-way.

(i) Station Operation - (DG) Provision should be made for convenient and efficient inter- and intra-modal transfer and transport of passengers, baggage and freight.

(j) *Availability and* Reliability - (DG) The design should have high system *availability and subsystem* reliability, maintainability and ease of inspection.

(k) Aesthetics - (DG) Attention to aesthetics should be evidences in the design to increase public acceptance and ensure consideration of economic impacts.

(l) Communications - (DG) The system will include provi-

sions for non-vital voice, data, and video communication capability.

(m) Human Factors - (DG) Human factors including the operator, passengers and maintenance considerations shall be evidenced in the design.

2.0 Vehicle Requirements

(a) Capacity - (DG) Vehicles of different sizes, configured to carry passengers and/or freight, should be feasible within the same basic design.

(b) Braking System - (MR) Vehicles must have redundant braking systems *and* must be fail-safe. *Normal braking of up to 0.2g shall be considered.*

(c) Structural Integrity - (MR) Vehicles must safely withstand high-speed impacts with small objects such as birds, debris, snow and ice. Vehicles must also have adequate fatigue life and low-speed crash worthiness *and shall sustain only minimum damage in a 5 mph impact.*

(d) On-Board Power - (DG) All power for normal hotel functions, controls, levitation, etc. *should* be transferred from the guideway. (MR) The vehicle must be equipped with emergency power for operation, as appropriate within the system safety plan.

(e) Emergency Systems - (MR) Vehicles must include systems for fire fighting, emergency lighting, HVAC, evacuation, communication, etc. as appropriate within the system safety plan.

(f) Instrumentation and Controls - (MR) Vehicles shall include instruments which monitor the integrity of the guideway (presence of debris, snow and ice, misalignment or deterioration of guideway, etc.) and the status of on-board systems (propulsion, levitation, guidance, power, safety, etc.). Data acquired should be *recorded and* fully integrated into vehicle and overall-system controls to allow appropriate response in emergency and normal operations. In normal operation, vehicles will be *monitored or* controlled from a central facility. However, vehicles will include manual controls for emergency and maintenance operations.

(g) Sanitary Facilities - (MR) Space must be provided for sanitary facilities, including a retention system.

3.0 Guideway Requirements

(a) Structural Integrity - (MR) Civil structure *(foundation and structure supporting the guideway)* shall have a minimum *50* year life. Consideration shall be given to structural integrity under earthquake and high-wind conditions.

(b) Configuration - (DG) Guideways will ***normally*** be elevated and have bi-directional capability *but must also accommodate near grade and underground applications.* Single guideways must include provision for passing vehicles and future expansion. Dual guideways must include crossovers to sustain partial service during routine maintenance and repair of local failures. The central facility will control crossovers and bi-directional traffic.

(c) Structure -(DG) To facilitate maintenance, repair of local failures, and eventual system upgrade, guideways should be of modular construction with an independent support structure. This support structure (foundations, piers, beams, connectors) should be designed to accommodate growth in traffic (see System Capacity). The design must also include means for vertical and lateral adjustment of guiding elements to maintain required tolerances.

(d) Vehicle Entry/Exit - (DG) Entry/exit to off-line stations, feeder lines and other main lines should minimize vehicle headway requirements and overall trip time.

(e) Instrumentation and Controls - (MR) Guideways shall include instruments which monitor guideway integrity (presence of debris, snow and ice, misalignment or deterioration of guideway, etc.), the status of its subsystems (propulsion, levitation, guidance, power, entries/exits, etc.) and the locations and velocities of all vehicles. Data acquired should be fully integrated into guideway and overall-system controls to allow response in both emergency and normal operations.

(f) Tunnels - (MR) Design of tunnels shall address issues of comfort, noise and safety, with special attention to vehicle entry and passing vehicles.

(g) Power Systems - (DG) Power systems should be sized to provide vehicle acceleration and braking capacity for all operating conditions and should be capable of meeting requirements for system capacity. Guideway power systems should be capable of sustaining vehicles at full cruising speed up sustained grades of 3.5:100, and provide vehicle propulsion at reduced speeds up a maximum grade of 10:100.

(h) Super-elevation - (MR) Super-elevated (banked) guideways must provide for safe operation of vehicles at all speeds from zero to the maximum design speed. Emergency evacuation must be possible from vehicles stopped in the curve.

Appendix A

Procedures for specifying ride motion environment for planned high speed magnetically levitated system
Based on methodology outlined in:
Peplar, Vallerie, Jacobson, Barber and Richards, 1978

In determining ride motion specifications for any fixed guideway system the two major factors which must be considered are:

- *the minimum level of ride quality which will be acceptable to the majority of the passengers, and*
- *the initial design and construction costs and ongoing maintenance costs which will be required to achieve and maintain this minimum level.*

The acceptability of the ride provided by the system is based on the physical characteristics of the ride:

- *linear and rotational accelerations*
- *acoustic noise*
- *temperature and humidity, and*
- *the passengers expectations with regard to the level of comfort and types of personal activity possible during the trip.*

The importance of passenger expectations cannot be overemphasized. Preliminary joint DOT/NASA research, "United States - Federal Republic of Germany Cooperative Study of Advanced Ground Vehicle Ride Quality, November 1979 (Revised), Report No. RS006-PM-79-31, E.D. Sussman et al," which related ride motion to passenger comfort found that the same motion levels which were perceived to be unacceptable when subjects thought the vehicle simulated was a jet passenger aircraft, were considered comfortable when the subjects were told that simulation was a high speed "train-like" magnetically levitated vehicle.

The simple application of ISO guidelines on the effects of shock and vibration to determine ride limits is extremely questionable because these guidelines do not correct for passenger expectations. Applications of the same ISO guidelines to different vehicles by Peplar et al provided profoundly different comfort ratings. A further limitation to the ISO guidelines is that they provide little useful guidance with regard to roll, pitch and yaw motion. These motions have been found to have a major impact on passenger comfort. The usefulness of the ISO guidelines is in ensuring that pure tone accelerations do not exceed the ISO boundaries corresponding to the trip length . In the case of an intercity system the limits should be based on a two hour boundary.

Procedures for determining the proportion of passengers which will find a system acceptable based on the comfort rating are derived from the plot on page 68 of the Pepler et al report. In *order to ensure that 90% of all passengers find the system acceptable, a composite comfort rating of C=3.0 is required. This corresponds to rating of somewhat comfortable on a scale where 1.0 is very comfortable and 7.0 is very uncomfortable.*

The value of C=3.0 can be used to determine the minimum acceptable ride, acoustic noise and temperature levels by application of the "composite equation" provided for the evaluation of proposed new travel modes and presented on page 74 of the Pepler document.

$$C=1.0 + .5wR + .[db(A)-65] + 17aT + 17aV$$

where wR = RMS Roll Rate
aT = RMS Transverse accel.
aV = RMS Vertical accel.
db(A) - decibels using A-weighting system

Using this methodology, "equicomfort contours" can be generated with the proviso that the vibration, temperature and noise levels are within the range of measurements the comfort equation was derived from. For applicability to an intercity maglev system, the range of motions and other variables (i.e., frequencies, etc.) should correspond to the ride environments measured by Pepler et al. For this case the most appropriate ride environment is that of the intercity passenger train (see page 33) for tangent track.

For example, applying this model to achieve a comfort rating of C=3.0 for a proposed maglev system provides the following restrictions to the ride environment for operations <u>on tangent guideway</u>. It should be noted the motion limits are appropriate for vibrations in the 0.1 to 25hz regime.

RMS roll rate	0.9 (deg/sec)
RMS Trans. Accel.	.06g
RMS Vert. Accel.	.05g
Noise	62 db(A)

The remaining terms may vary as follows:

RMS pitch rate	0.9 to 2.6 (deg/sec)
RMS yaw rate	0.9 to 2.6 (deg/sec)
RMS Long. Accel.	.007 to .022 g
Temperature	68 to 82 deg. F

<u>No useful ride data exists for intercity rail for sustained transverse unbalanced acceleration on super-elevated guideway (time periods considerably in excess of 0.1 seconds). The only models available which incorporate such data were taken using transit buses which are of very limited usefulness.</u>

APPENDIX B -- STAFF SCIENTIST/ENGINEER CONTACTS

VEHICLE SYSTEMS

Suspension Systems, John T. Harding, Ph.D.
(202)366-6144 FAX (202)366-7150 (DOT/FRA)

Superconducting Magnets, Howard T. Coffey, Ph.D.
(708)972-5633 FAX (708)972-3443 (DOE/Argonne N.L.)

Power, Propulsion and Braking Systems, Ray Wlodyka
(617)494-2400 FAX (617)494-3066 (DOT/TSC)

Vehicle Configuration and Structure, Thomas D. Schultz
(202)366-0466 FAX (202)366-7150 (DOT/FRA)

GUIDEWAY SYSTEMS, Carol Youkey
(205)722-1510 FAX (205)895-3089 (DOD/CEHND)

CONTROL SYSTEMS, Robert Dorer
(617)494-2596 FAX (617)494-3066 (DOT/TSC)

SYSTEMWIDE CONSIDERATIONS

Electromagnetic Fields/Interference/Compatibility,
Lennart E. Long, C.P.P.
(617)494-2251 FAX (617)494-3066 (DOT/TSC)

Environment (not Climatic Effects), Mark Yachmetz
(202)366-9332 FAX (202)366-0646 (DOT/FRA)

Vehicle-Guideway Interface, John Loyd
(205)895-5670 FAX (205)895-3089 (DOD/CEHND)

Climatic Effects, James H. Lever, Ph.D.
(603)646-4325 FAX (603)646-4278 (DOD/CRREL)

Test Facilities, Arne J. Bang
(202)366-0457 FAX (202)366-7150 (DOT/FRA)

Human Factors, Don Sussman, Ph.D.
(617)494-2413 FAX (617)494-3066 (DOT/TSC)

Safety and Emergency Procedures, Arne J. Bang
(202)366-0457 FAX (202)366-7150 (DOT/FRA)

INNOVATIVE CONCEPTS, John T. Harding, Ph.D.
(202)366-6144 FAX (202)366-7150 (DOT/FRA)

APPENDIX C -- REFERENCES

FRA OHSGT AND UMTA MAGLEV RESEARCH REPORTS

SAMPLE RECORD

Technical Report

RECORD TYPE	DA
TRIS ACCESSION NUMBER	475192 DA
TITLE	ROAD PROFILE STUDY. FINAL REPORT
AUTHORS	Cumbaa, SL
CORPORATE SOURCE	Louisiana Dept of Transportation & Development P.O. Box 94245, Capitol Station Baton Rouge Louisiana 70804; Federal Highway Administration 400 7th Street, SW Washington D.C. 20590
PUBLICATION YEAR	Feb 1986 n.p.
REPORT NUMBER	REPORT NO: FHWA/LA-86/185; Rept No 185
CONTRACT NUMBER	CONTRACT NO: Study No 83-1P(B); HP&R
	SUBFILE: HRIS
AVAILABILITY	AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (NTIS order number)
ABSTRACT	This study was undertaken to evaluate the overall usefulness of the Rainhart profilograph as a roughness measuring device, and to determine its ability to profile the roadway surface. Comparison testing was conducted utilizing the profilograph along with the 10-ft. rolling straightedge and the Mays Ride Meter on both portland cement concrete and hot mix asphaltic concrete surfaces. The profiling ability of the profilograph was studied by testing it over a surface with known (induced) areas of roughness. It was found that the digital counters of the profilograph are un-repeatable, and therefore not useable. The profilograph's graphical trace was found to be very repeatable, and when evaluated using a 0.1-in. blanking band, to correlate well with both the 10-ft. rolling straightedge and the Mays Ride Meter. It was determined that in most cases the profilograph produces a graphical trace which closely resembles the actual surface profile of the roadway. Recommendation for the development of profilograph "roughness" specifications and for profilograph utilization are included in this report.

The DOT Headquarters library is located at 400 Seventh St. SW, Washington, DC 20590, Room 2200, Tel. (202)366-0746

325729 DA
COMPARISONS BETWEEN DESIGNS FOR SINGLE-SIDED LINEAR ELECTRIC MOTORS: HOMOPOLAR SYNCHRONOUS AND INDUCTION. PHASE III
Nondahl, TA; Richter, E
General Electric Company P.O. Box 43 Schenectady New York 12301; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Sep 1980 Final Rpt. 121p Figs. Tabs. 10 App.
REPORT NO: FRA/ORD-80/54
CONTRACT NO: DOT-FR-64147; Contract
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 81 116188)
A design study of two types of single-sided (with a passive rail) linear electric machine designs, namely homopolar linear synchronous machines (LSM's) and linear induction machines (LIM's), is described. It is assumed the machines provide tractive effort for several types of light rail vehicles and locomotives. These vehicles are wheel supported and require tractive powers ranging from 200 kW to 3735 kW and top speeds ranging from 112 km/hr to 400 km/hr. All designs are made according to specified magnetic and thermal criteria. The LSM advantages are a higher power factor, much greater restoring forces for track misalignments, and less track heating. The LIM advantages are no need to synchronize the excitation frequency precisely to vehicle speed, simpler machine construction, and a more easily anchored track structure. The relative weights of the two machine types vary with excitation frequency and speed; low frequencies and low speeds favor the LSM. The effect of variations in several LSM design parameters are shown to illustrate trends in machine dimensions, track weight, and commutating reactance. The details of the LSM design programs are described and a Fortran IV listing of the programs is provided.

325728 DA
PERFORMANCE OF A SINGLE-SIDED LINEAR INDUCTION MOTOR WITH SOLID BACK IRON AND WITH VARIOUS MISALIGNMENTS. VOLUME 2- APPENDIX B-PART 2
Kliman, GB; Mischler, WR; Oney, WR
General Electric Company P.O. Box 43 Schenectady New York 12301; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Sep 1980 Final Rpt. 272p
REPORT NO: FRA/ORD-80/53-2-2; SRD-78-069
CONTRACT NO: DOT-FR-64147; Contract
SUBFILE: RRIS
AVAILABLE FOR PERUSAL AT THE DOT HEADQUARTERS LIBRARY
A test facility was designed and built to measure all aspects of the performance of a single-sided high-speed linear induction motor with solid back iron over a wide range of frequency, speed, and excitation. The facility was equipped and instrumented to measure all the usual performance parameters plus all of the six-axis forces in normal operation and, when displaced, in the remaining five degrees of freedom (air gap, lateral, pitch, roll, and yaw). Performance in the normal position was compared to the mesh/matrix prediction. Generally good agreement was obtained between measured and predicted values of thrust and efficiency. Differences between predicted and measured thrust (especially at high slips) were related to the solid back iron and skin saturation. Agreement between predicted and measured normal forces was not satisfactory. The six-axis force measuring system was thoroughly analyzed to determine the range of validity of the measurements and the errors inherent in using a sector motor to simulate a flat linear motor.

325727 DA
PERFORMANCE OF A SINGLE-SIDED LINEAR INDUCTION MOTOR WITH SOLID BACK IRON AND WITH VARIOUS MISALIGNMENTS. VOLUME 2- APPENDIX B-PART 1
Kliman, GB; Mischler, WR; Oney, WR
General Electric Company P.O. Box 43 Schenectady New York 12301; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Sep 1980 Final Rpt. 289p
REPORT NO: FRA/ORD-80/53-2-1; SRD-78-069
CONTRACT NO: DOT-FR-64147; Contract
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 81 119463)
A test facility was designed and built to measure all aspects of the performance of a single-sided high-speed linear induction motor with solid

back iron over a wide range of frequency, speed, and excitation. The facility was equipped and instrumented to measure all the usual performance parameters plus all of the six-axis forces in normal operation and, when displaced, in the remaining five degrees of freedom (air gap, lateral, pitch, roll, and yaw). Performance in the normal position was compared to the mesh/matrix prediction. Generally good agreement was obtained between measured and predicted values of thrust and efficiency. Differences between predicted and measured thrust (especially at high slips) were related to the solid back iron and skin saturation. Agreement between predicted and measured normal forces was not satisfactory. The six-axis force measuring system was thoroughly analyzed to determine the range of validity of the measurements and the errors inherent in using a sector motor to simulate a flat linear motor.

325726 DA
PERFORMANCE OF A SINGLE-SIDED LINEAR INDUCTION MOTOR WITH SOLID BACK IRON AND WITH VARIOUS MISALIGNMENTS. PHASE II- VOLUME 1
Kliman, GB; Mischler, WR; Oney, WR
General Electric Company P.O. Box 43 Schenectady New York 12301; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Sep 1980 Final Rpt. 103p Figs. 8 Tab. 2 App.
REPORT NO: FRA/ORD-80/53-1; SRD-78-069
CONTRACT NO: DOT-FR-64147; Contract
SUBFILE: RRIS
AVAILABLE FOR PERUSAL AT THE DOT HEADQUARTERS LIBRARY
A test facility was designed and built to measure all aspects of the performance of a single-sided high-speed linear induction motor with solid back iron over a wide range of frequency, speed, and excitation. The facility was equipped and instrumented to measure all the usual performance parameters plus all of the six-axis forces in normal operation and, when displaced, in the remaining five degrees of freedom (air gap, lateral, pitch, roll, and yaw). Performance in the normal position was compared to the mesh/matrix prediction. Generally good agreement was obtained between measured and predicted values of thrust and efficiency. Differences between predicted and measured thrust (especially at high slips) were related to the solid back iron and skin saturation. Agreement between predicted and measured normal forces was not satisfactory. The six-axis force measuring system was thoroughly analyzed to determine the range of validity of the measurements and the errors inherent in using a sector motor to simulate a flat linear motor.

325725 DA
PERFORMANCE OF A LINEAR SYNCHRONOUS MOTOR WITH LAMINATED TRACK POLES AND WITH VARIOUS MISALIGNMENTS. PHASE I-VOLUME 6
Mischler, WR; Nondahl, TA
General Electric Company P.O. Box 43 Schenectady New York 12301; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Sep 1980 Final Rpt. 236 p 1 App.
REPORT NO: FRA/ORD-80/52-6; SRD-78-102
CONTRACT NO: DOT-FR-64147; Contract
SUBFILE: RRIS
AVAILABLE FOR PERUSAL AT THE DOT HEADQUARTERS LIBRARY
A test facility was designed and built to measure the performance of a single-sided high speed homopolar Linear Synchronous Motor with laminated pole pieces over a wide range of frequency and excitation levels. The facility was instrumented to measure performance at the machine terminals, flux density in the air gap and machine, and forces in all six axes. The machine was tested under nominal conditions and with perturbations in five degrees of freedom: air gap, lateral, pitch, roll, and yaw. Equivalent circuit parameters and flux form coefficents were measured and compared to design values. Poor correlation forced a revision of the design programs. The modeling of the finite interpolar gap and interpolar leakage flux led to good agreement between test and revised design values. The test data show a high power factor, the absence of end effects, and a strong tendency of the machine to remain properly aligned relative to the track, with the exception of a destabilizing pitch torque.

325724 DA
PERFORMANCE OF A LINEAR SYNCHRONOUS MOTOR WITH LAMINATED TRACK POLES AND WITH VARIOUS MISALIGNMENTS. PHASE I-VOLUME 5
Mischler, WR; Nondahl, TA
General Electric Company P.O. Box 43 Schenectady New York 12301; Federal

Railroad Administration Office of Research and Development Washington D.C. 20590
Sep 1980 Final Rpt. 298p 1 App.
REPORT NO: FRA/ORD-80/52-5; SRD-78-102
CONTRACT NO: DOT-FR-64147; Contract
SUBFILE: RRIS
AVAILABLE FOR PERUSAL AT THE DOT HEADQUARTERS LIBRARY
A test facility was designed and built to measure the performance of a single-sided high speed homopolar Linear Synchronous Motor with laminated pole pieces over a wide range of frequency and excitation levels. The facility was instrumented to measure performance at the machine terminals, flux density in the air gap and machine, and forces in all six axes. The machine was tested under nominal conditions and with perturbations in five degrees of freedom: air gap, lateral, pitch, roll, and yaw. Equivalent circuit parameters and flux form coefficients were measured and compared to design values. Poor correlation forced a revision of the design programs. The modeling of the finite interpolar gap and interpolar leakage flux led to good agreement between test and revised design values. The test data show a high power factor, the absence of end effects, and a strong tendency of the machine to remain properly aligned relative to the track, with the exception of a destabilizing pitch torque.

325723 DA
PERFORMANCE OF A LINEAR SYNCHRONOUS MOTOR WITH LAMINATED TRACK POLES AND WITH VARIOUS MISALIGNMENTS. PHASE I-VOLUME 4
Mischler, WR; Nondahl, TA
General Electric Company P.O. Box 43 Schenectady New York 12301; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Sep 1980 Final Rpt. 242p 1 App.
REPORT NO: FRA/ORD-80/52-4; SRD-78-102
CONTRACT NO: DOT-FR-64147; Contract
SUBFILE: RRIS
AVAILABLE FOR PERUSAL AT THE DOT HEADQUARTERS LIBRARY
A test facility was designed and built to measure the performance of a single-sided high speed homopolar Linear Synchronous Motor with laminated pole pieces over a wide range of frequency and excitation levels. The facility was instrumented to measure performance at the machine terminals, flux density in the air gap and machine, and forces in all six axes. The machine was tested under nominal conditions and with perturbations in five degrees of freedom: air gap, lateral, pitch, roll, and yaw. Equivalent circuit parameters and flux form coefficients were measured and compared to design values. Poor correlation forced a revision of the design programs. The modeling of the finite interpolar gap and interpolar leakage flux led to good agreement between test and revised design values. The test data show a high power factor, the absence of end effects, and a strong tendency of the machine to remain properly aligned relative to the track, with the exception of a destabilizing pitch torque.

325722 DA
PERFORMANCE OF A LINEAR SYNCHRONOUS MOTOR WITH LAMINATED TRACK POLES AND WITH VARIOUS MISALIGNMENTS. PHASE I-VOLUME 3
Mischler, WR; Nondahl, TA
General Electric Company P.O. Box 43 Schenectady New York 12301; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Sep 1980 Final Rpt. 324p 1 App.
REPORT NO: FRA/ORD-80/52-3; SRD-78-102
CONTRACT NO: DOT-FR-64147; Contract
SUBFILE: RRIS
AVAILABLE FOR PERUSAL AT THE DOT HEADQUARTERS LIBRARY
A test facility was designed and built to measure the performance of a single-sided high speed homopolar Linear Synchronous Motor with laminated pole pieces over a wide range of frequency and excitation levels. The facility was instrumented to measure performance at the machine terminals, flux density in the air gap, lateral, pitch, roll, and yaw. Equivalent circuit parameters and flux form coefficients were measured and compared to design values. Poor correlation forced a revision of the design programs. The modeling of the finite interpolar gap and interpolar leakage flux led to good agreement between test and revised design values. The test data show a high power factor, the absence of end effects, and a strong tendency of the machine to remain properly aligned relative to the track, with the exception of a destabilizing pitch torque.

325721 DA
PERFORMANCE OF A LINEAR SYNCHRONOUS MOTOR WITH LAMINATED TRACK POLES AND WITH VARIOUS MISALIGNMENTS. PHASE I-VOLUME 2
Mischler, WR; Nondahl, TA
General Electric Company P.O. Box 43 Schenectady New York 12301; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Sep 1980 Final Rpt. 352p 1 App.
REPORT NO: FRA/ORD-80/52-2; SRD-78-102
CONTRACT NO: DOT-FR-64147; Contract
SUBFILE: RRIS
AVAILABLE FOR PERUSAL AT THE DOT HEADQUARTERS LIBRARY
A test facility was designed and built to measure the performance of a single-sided high speed homopolar Linear Synchronous Motor with Laminated pole pieces over a wide range of frequency and excitation levels. The facility was instrumented to measure performance at the machine terminals, flux density in the air gap and machine, and forces in all six axes. The machine was tested under nominal conditions and with perturbations in five degrees of freedom: air gap, lateral, pitch, roll, and yaw. Equivalent circuit parameters and flux form coefficients were measured and compared to design values. Poor correlation forced a revision of the design programs. The modeling of the finite interpolar gap and interpolar leakage flux led to good agreement between test and revised design values. The test data show a high power factor, the absence of end effects, and a strong tendency of the machine to remain properly aligned relative to the track, with the exception of a destabilizing pitch torque.

325720 DA
PERFORMANCE OF A LINEAR SYNCHRONOUS MOTOR WITH LAMINATED TRACK POLES AND WITH VARIOUS MISALIGNMENTS. PHASE I-VOLUME 1
Mischler, WR; Nondahl, TA
General Electric Company P.O. Box 43 Schenectady New York 12301; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Sep 1980 Final Rpt. 115p Figs. 5 Tab. 1 App.
REPORT NO: FRA/ORD-80/52-1; SRD-78-102
CONTRACT NO: DOT-FR-64147; Contract
SUBFILE: RRIS
AVAILABLE FOR PERUSAL AT THE DOT HEADQUARTERS LIBRARY
A test facility was designed and built to measure the performance of a single-sided high speed homopolar Linear Synchronous Motor with laminated pole pieces over a wide range of frequency and excitation levels. The facility was instrumented to measure performance at the machine terminals, flux density in the air gap and machine, and forces in all six axes. The machine was tested under nominal conditions and with perturbations in five degrees of freedom: air gap, lateral, pitch, roll, and yaw. Equivalent circuit parameters and flux form coefficients were measured and compared to design values. Poor correlation forced a revision of the design programs. The modeling of the finite interpolar gap and interpolar leakage flux led to good agreement between test and revised design values. The test data show a high power factor, the absence of end effects, and a strong tendency of the machine to remain properly aligned relative to the track, with the exception of a destabilizing pitch torque.

319061 DA
EFFECT OF MACHINE LENGTH ON THE PERFORMANCE OF LINEAR INDUCTION MOTORS: AN EXPERIMENTAL INVESTIGATION
Bevan, RJA
AiResearch Manufacturing Company 2525 West 190th Street Torrance California 90509; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Jan 1979 Final Rpt. 247 p. Figs. Tabs. 17 Ref. 12 App.
REPORT NO: FRA/ORD-79/07; 77-14572
CONTRACT NO: DOT-FR-64226; Contract
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 80 156243)
This report describes the full-scale testing of a 10-pole, double-sided linear induction motor, modified to permit excitation of 9, 5, 4, or 2 poles in addition to full 10-pole excitation. Testing in reduced-pole configurations enabled the effect of a discontinuous excitation at the front and rear of the motor to be investigated, as well as the validity of certain mathematical models that assume infinite primary iron extending in the forward and reverse directions. A mathematical model of the motor is

also presented that shows good correlation with test results. The motor had a peak thrust capability of 15.3 kN at 60 m/s at an excitation current of 2000 A.

179289 DA
SELECTED BIBLIOGRAPHY OF WORLD LITERATURE ON ELECTRIC TRACTION FOR RAILROADS, 1970-1976
Macie, TW
Jet Propulsion Laboratory; 4800 Oak Grove Drive; Pasadena; California; 91103
Aug 1977 Bibliog. 146 pp
REPORT NO: FRA/ORD-77/42
CONTRACT NO: DOT-AR-30006 Amend 5; Contract
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 284160)
No Abstract. Prepared for U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Washington, D.C.

179284 DA
PHASE IIIC--TEST & DEMONSTRATION PROTOTYPE TRACKED AIR CUSHION VEHICLE (PTACV)
Smith, AK; Dallas, J; Dynes, R; Stott, R; Samusson, L
Rohr Industries, Incorporated; Foot of H Street; Chula Vista; California ; 92010
Nov 1977 Final Rpt. 215 pp Figs. Tabs. 15 Ref. 2 App.
REPORT NO: FRA/ORD-78/03
CONTRACT NO: DOT-FR-54089; Contract
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 279970)
A six year multi-phased program for design, development and test of a prototype tracked air cushion vehicle was culminated in a six month test and demonstration under Phase IIIC. Descriptions of the various major sub-systems are presented with design and operational performance data. Technical data covering test objectives, descriptions and results are furnished on a wide variety of functional assemblies, subsystems and performance conditions. Physical characteristics were measured for accelerations, braking, aerodynamic drag, ride comfort, acoustical quality, reliability and maintainability performance. System description and proposed system applications were surveyed and presented to selected government representatives. Prepared for U.S. Department of Transportation, Federal Railroad Administration. Related information in report deliverables under Phases I through IIIB of contracts DOT-UT-10031; and DOT-FR-40022.

179283 DA
VIBRATION ASPECTS OF RIDE QUALITY MODELING FOR THE DOT PTACV--THEORY AND EXPERIMENT
Katz, R
Mitre Corporation; 1820 Dolley Madison Boulevard; McLean; Virginia; 22101
Dec 1977 Tech Rpt. 51 pp 29 Fig. 2 Tab. 9 Ref.
REPORT NO: FRA/ORD-78/02; MTR-7692
CONTRACT NO: DOT-FR-54090; Contract
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 279846)
An important aspect of passenger ride comfort in a transportation vehicle is the acceleration level of the passenger cabin. In order to incorporate ride quality into the design process of such vehicles, it is necessary to have reasonably validated analytical models to predict the acceleration levels at frequencies which affect passenger ride comfort. The purpose of this report is to discuss the suitability of analytical models used to predict the heave acceleration in the passenger cabin of The Department of Transportation's Prototype Tracked Air Cushion Vehicle (PTACV). The basis of this evaluation is a comparison of theoretical predictions from an analytical model, typical of those in common usage today, with measured response accumulated during testing of the PTACV on its test track. Prepared for U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Washington, D.C.

179282 DA
TLV STATUS REPORT

Katz, R
Mitre Corporation; 1820 Dolley Madison Boulevard; McLean; Virginia; 22101
Oct 1977 Tech Rpt. 142 pp 52 Fig. 37 Ref.
REPORT NO: FRA/ORD-78/01; MTR-7599
CONTRACT NO: DOT-FR-54090; Contract
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 279845)
The worldwide status of Tracked Levitated Vehicle (TLV) technology and an assessment of its development, sponsored by the Advanced Technology Program within the Office of Research and Development in FRA, is presented here. This report along with a TLV Technology Workshop sponsored by the Office of University Research represent a continuing and coordinated effort by the Department of Transportation to keep abreast of the state of worldwide developments in this technology. The first chapter, entitled "An Overview of Worldwide Research Programs of Noncontacting Suspensions for Ground Transportation Vehicles", describes various maglev and air cushion suspension test facilities in use throughout the world. The second chapter, entitled "TLV Technology Status Report" discusses the status of the overall technology, in the judgment of MITRE/METREK. The purpose of this report is to place the worldwide research efforts in perspective as they address the outstanding technical problems as a whole. This will provide the reader with a tool for assessing target areas for future research which complement the ongoing worldwide efforts. This report uses the SI (metric) units. Prepared for U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Washington, D.C.

179123 DA
COMPARISON OF LINEAR INDUCTION MOTOR THEORIES FOR THE LIMRV AND TLRV MOTORS
Stickler, JJ
Transportation Systems Center; 55 Broadway; Cambridge; Massachusetts; 02142
Jan 1978 Final Rpt. 132 pp 39 Fig. 21 Tab. 8 Ref. 1 App.
REPORT NO: DOT-TSC-FRA-77-21; FRA/ORD-77/68
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 292654)
The Oberretl, Yamamura, and Mosebach theories of the linear induction motor are described and also applied to predict performance characteristics of the TLRV & LIMRV linear induction motors. The effect of finite motor width and length on performance predictions is examined for each theory. The edge and end effects are shown to play a dominant role in determining motor performance. The LIM thrusts predicted by the Oberretl, Yamamura, and Mosebach computer models are in reasonable agreement over most of the LIM speed range. The Oberretl theory tends to predict somewhat lower thrust values than the Yamamura and Mosebach theories; possible causes for the divergent thrust predictions are discussed. Computer listings for the Oberretl and Yamamura linear induction motor theories are presented in the appendix. Prepared for U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Washington, D.C.

170286 DA
FEASIBILITY STUDY OF A 15,000-KVA CAPACITOR-ASSISTED POWER UNIT FOR INDUCTION MOTOR PROPULSION
Powell, RB; Kaman, GP
AiResearch Manufacturing Company; 2525 West 190th Street; Torrance; California; 90509
Jan 1977 Study Rpt. 173 pp Figs. 10 Tab. 5 App.
REPORT NO: FRA/ORD-77/43
SUBFILE: RRIS
AVAILABLE FOR PERUSAL AT THE DOT HEADQUARTERS LIBRARY
This report describes results of a technical study to identify and describe feasible linear induction motor propulsion system (LIMPS) alternatives for attaining desired maximum vehicle speed within a given guideway length. The study deals with an original concept of two identical LIMPS modules and whether this concept remains the most effective means to produce thrust for a 300-mph vehicle, as well as 11 other candidate concepts, all subject to the fixed design constraints of limited vehicle space, 8-kV electrical power supply, and fixed vehicle, guideway, and reaction rail interfaces. The following factors were among those identified as having significant influence on the comparative results: 1. Thrust degradation at high speeds (end effects) has the same result on performance

as LIM operation at a lower slip value. Since the maximum frequency of the voltage applied to the LIM is limited by the present SC design, a longer LIM pole pitch is the only practical method of reducing the impact of end effects. 2. A change in the effective LIM operating point shifts both real and reactive power demands. 3. The power ratings of new, recently developed thyristors make possible the design and manufacture of a single dc-link converter that will supply all the real power required by the LIM, resulting in substantially lower converter weight and volume. 4. Static capacitors can replace part of the power factor correcting function of the synchronous condenser at a fraction of the cost. Prepared for U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Washington, D.C.

170280 DA
DESIGN, DEVELOPMENT, FABRICATION, AND TESTING OF A SYNCHRONOUS CONDENSER FOR A HIGH-POWER THREE-PHASE TRACTION DRIVE
Brown, TE; Grahl, RF
AiResearch Manufacturing Company; 2525 West 190th Street; Torrance; California; 90509
Dec 1976 Final Rpt. 100 pp Figs. 6 Tab. 2 Ref.
REPORT NO: FRA/ORD 76-266
CONTRACT NO: DOT-FR-00029; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 284397)
This report documents the synchronous machine, referred to as a synchronous condenser, which, in the tracked levitated research vehicle (TLRV), provides line commutation for the inverter and power factor correction for the linear induction motor. The machine also incorporates features permitting its use as a synchronous alternator or motor in a wide range of conventional and advanced ground transportation applications. The machine provides a very high specific power density (1.7 kVA/lb) and voltage rating (7150 V, line-to-line, RMS), principally through the use of direct liquid cooling of both the stator and rotor windings and other elements of the machine (i.e., bearings, brushes, sliprings, etc.). Deionized water is used as the cooling liquid. Prepared for U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Washington, D.C.

170063 DA
LINEAR INDUCTION MOTOR RESEARCH VEHICLE REACTION RAIL CURRENT AND AIRGAP FLUX DISTRIBUTION TEST
Powell, RB; McConville, JH
AiResearch Manufacturing Company; 2525 West 190th Street; Torrance; California; 90509
Jun 1977 Final Rpt. 80 pp Figs. Tabs. 5 Apps.
REPORT NO: FRA/ORD 77-40
CONTRACT NO: DOT-FR-40016; Contract
SUBFILE: RRIS
AVAILABLE FOR PERUSAL AT THE DOT HEADQUARTERS LIBRARY
Special instrumentation was installed on the LIMRV reaction rail at the Pueblo, Colorado, Transportation Test Center and vehicle test runs were made to acquire and record information on secondary currents, airgap flux, and sidebar voltages. The data thus obtained is shown in the form of oscillographic tracings. Medium-speed (approx 85 mph) and high-speed (approx 190 mph) passes over the instrumented section of reaction rail were executed. Test findings are presented in a form suitable for detailed study and evaluation by interested analysts. Prepared for U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Washington, D.C.

168985 DA
COMPARISON OF EXPERIMENTAL AND THEORETICAL REACTION RAIL CURRENTS, RAIL VOLTAGES, AND AIRGAP FIELDS FOR THE LINEAR INDUCTION MOTOR RESEARCH VEHICLE
Elliott, DG
Jet Propulsion Laboratory 4800 Oak Grove Drive Pasadena California 91103 National Aeronautics and Space Administration 700 Independence Avenue, SW Washington D.C. 20590; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Jul 1977 Final Rpt. 84 pp
REPORT NO: FRA/ORD-77/33
CONTRACT NO: NAS7-100; Contract
SUBFILE: NTIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal

Road Springfield Virginia 22161 (PB 274039)
Measurements of reaction rail currents, reaction rail voltages, and airgap magnetic fields in tests of the Linear Induction Motor Research Vehicle (LIMRV) were compared with theoretical calculations from the mesh/matrix theory. It was found that the rail currents and magnetic fields predicted by the theory are within 20 percent of the measured currents and fields at most motor locations in most of the runs, but differ by as much as a factor of two in some cases. The most consistent difference is a higher experimental than theoretical magnetic field near the entrance of the motor, and a lower experimental than theoretical magnetic field near the exit. The observed differences between the theoretical and experimental magnetic fields and currents do not account for the differences of as much as 26 percent between the theoretical and experimental thrusts. (Color illustrations reproduced in black and white)

168021 DA
TENTH AND FINAL REPORT ON THE HIGH SPEED GROUND TRANSPORTATION ACT OF 1965
Federal Railroad Administration; Office of Research and Development; Washington; D.C.; 20590
Oct 1977 33 pp 15 Fig. 1 App.
REPORT NO: FRA/ORD-77/27
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 271508)
This summary of information presented in Report FRA/ORD-77/27 traces the decade of development of unconventional high-speed ground transportation vehicles. The section on Advanced Systems discusses system engineering, tracked air cushion vehicles, tube vehicles, suspended vehicles and multimodal concepts involving passenger service. The section on Advanced Technology describes work with linear electric motors, guideways, power conditioning, controls, obstacle detection and communications. An Appendix explains current FRA advanced systems and advanced technology research programs. A summary of Ten Years of Advanced Research and Development by the Federal Railroad Administration.

153067 DA
SELECTED BIBLIOGRAPHY OF WORLD LITERATURE ON ELECTRIC TRACTION FOR RAILROADS. (1970-1975 PERIOD)
Macie, TW
Jet Propulsion Laboratory; California Institute of Technology, 4800 Oak Grove Drive; Pasadena; California; 91103
Nov 1976 Bibliog. 85 pp
REPORT NO: FRA-OR&D 76-296
CONTRACT NO: DOT-AR-30006 Amend 4; Contract
SUBFILE: RRIS; NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 265469)
The purpose of this task was to review selected world literature on electric traction and railroad electrification of 1970-1975 period and prepare abstracts of the most important articles describing the status of foreign technology in selected areas of interest. This document lists all these abstracts. In addition, nine (9) volumes of photocopied original articles are filed with Mr. M. Guarino, Program Manager, Electrical Traction, FRA, RRD-21, Washington, D.C. 20590 for reference. Compilation of this bibliography was sponsored by the FRA, Office of Research, Development and Demonstration, U.S. DOT.

150468 DA
A COMPARISON OF LIMRV LIM GUIDANCE SYSTEM EXPERIMENTAL DATA WITH MATHEMATICALLY PREDICTED VALUES USING REACTION RAIL SURVEY DATA
Muhlenberg, JD
Mitre Corporation Westgate Research Park McLean Virginia 22101; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Oct 1975 Tech. Rpt. 52 pp
REPORT NO: MTR-6618; FRA/ORD-76/25
CONTRACT NO: DOT-FR-30015; Contract
SUBFILE: NTIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 261921)
This document discusses the survey of 1,000 feet of Linear Induction Motor Research Vehicle (LIMRV) reaction rail at the Department of Transportation Test Center in Pueblo, Colo., and a comparison of experimental data from test runs of the LIMRV LIM guidance system with

theoretical predictions using the survey data as an input to a mathematical model. While some deviations from predicted values were observed, in general the correspondence between experimental data and predictions was excellent.

147579 DA
THE IMPACT OF THE U.S. ENERGY SITUATION ON HIGH SPEED GROUND TRANSPORTATION
Fraize, WE
Mitre Corporation; Westgate Research Park; McLean; Virginia; 22101
Dec 1975 Tech. Rpt. 41 pp 14 Fig. 3 Tab. 17 Ref. 1 App.
REPORT NO: FRA-OR&D-75-63
CONTRACT NO: DOT-FR-30015; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 261805)
U.S. energy supply issues for the next few decades are summarized with a view toward their impact on high speed ground transportation (HSGT) modes. As background, the energy characteristics of intercity passenger modes, including 300 mph tracked levitated vehicle (TLV) systems, are presented and discussed. In the short and mid terms (through 1985 or 1990), energy shortages are seen to impact HSGT modes mainly through increased operating (fuel) costs; and the need for greater capacity flexibility. In the long term, HSGT modes may have to adapt to non-fossil fuels. Research topics for addressing energy impacts on HSGT are suggested. Research sponsored by the FRA, Office of Research, Development and Demonstration.

147578 DA
THE AIR-CORE LINEAR SYNCHRONOUS MOTOR--AN ASSESSMENT OF CURRENT DEVELOPMENT
Skalski, CA
Mitre Corporation; Westgate Research Park; McLean; Virginia; 22101
Jun 1976 Final Rpt. 144 pp Figs. Tabs. 59 Ref. 5 App.
REPORT NO: FRA-OR&D-76-260
CONTRACT NO: DOT-FR-54090; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 261770)
The development of the air-core linear synchronous motor (LSM) is examined primarily on the basis of work done in the United States and Canada during the past five years. The outstanding performance features of these motors are demonstrated in terms of a simple theory, numerous design examples, and discussions of practical aspects. Comparisons to iron-core LSMs and linear induction motors are made. Also, the possibility of using air-core LSMs as an alternative to conventional railroad electrification techniques is pointed out. Research sponsored by the FRA, Office of Research and Development.

147576 DA
LINEAR INDUCTION MOTOR RESEARCH VEHICLE REACTION RAIL EDGE EFFECT INVESTIGATION. THE EFFECT OF RAIL SLOTTING
Powell, RB
AiResearch Manufacturing Company of California; 2525 West 190th Street; Torrance; California; 90509
Apr 1976 Final Rpt. 28 pp Figs. Tabs. 8 Ref. 1 App.
REPORT NO: FRA-OR&D-76-263
CONTRACT NO: DOT-FR-40016; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 261811)
The purpose of this investigation was to obtain full-scale linear induction motor performance data with a slotted reaction rail. The motor thrust characteristics were determined with two different airgap widths at each of two different slot pitches. Test results showed essentially no variation in motor thrust characteristics with a slotted vs. an unslotted reaction rail. On the basis of this investigation (35 separate test runs were performed) it is concluded that slotting the reaction rail does not enhance LIM performance. This is a significant finding because slotting increases the cost of reaction rail fabrication. Research sponsored by the Federal Railroad Administration, Office of Research and Development.

147572 DA
LINEAR INDUCTION MOTOR RESEARCH VEHICLE SPEED UPGRADING TESTS (190 TO 250 MPH)

Chi, CC
AiResearch Manufacturing Company of California; 2525 West 190th Street; Torrance; California; 90509
Jun 1976 Final Rpt. 102 pp Figs. Tabs. 6 Ref. 1 App.
REPORT NO: FRA-OR&D 76-268
CONTRACT NO: DOT-FR-30026; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 261852)
The linear induction motor research vehicle (LIMRV) was subjected to a series of test runs at speeds of 190 to 250 mph on the Department of Transportation 6.2-mile-long, standard gauge railroad track at the Transportation Test Center, Pueblo, Colorado. High-speed dynamic performance data on the vehicle, trucks, suspension systems, and LIM guidance system were acquired by means of instrumentation that measured accelerations and displacements. For these tests the LIMRV was fitted with two jet engines that enabled it to accelerate to high speeds during the first 2.3 miles of travel, leaving nearly 4 miles of track for constant-speed data collection and braking. The LIMRV operated in a fully stable manner dynamically up to the maximum speed attained, 255.7 mph. Sufficient data was collected so that a safe LIMRV operating profile could be constructed as a baseline for conducting LIM electrical performance tests with full confidence in the vehicle's dynamic stability up to its design speed of 250 mph. Research was sponsored by the Federal Railway Administration, Office of Research and Development.

147397 DA
LINEAR INDUCTION MOTOR ELECTRICAL PERFORMANCE TEST
Powell, RB
AiResearch Manufacturing Company 2525 West 190th Street Torrance California 90509; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Jun 1976 Final Rpt. 161 pp
REPORT NO: 75-11919-Rev-1; FRA/ORD-76/265
CONTRACT NO: DOT-FR-40016; Contract
SUBFILE: NTIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 261856)
This report describes the electrical performance characteristics of a 2500-hp (at 250 mph) linear induction motor (LIM), based on data acquired while propelling the LIM research vehicle over a 0-to-250-mph speed range. Pertinent LIM design information is included to enable independent investigators to correlate their mathematical models with the test data published herein. The principal end product of this effort is tabulated LIM performance, in terms of thrust, voltage, power factor, efficiency, input and output power, velocity, and percent slip at five excitation frequencies and at 1-Hz slip frequency increments, with all data referred to a 2000-A primary current. From the acquired data the following information was derived and included in this report: LIM performance characteristics (thrust vs slip at constant current, power factor vs slip, and efficiency vs slip), voltage- and current-source presentation of LIM data, influence of LIM end effects, and other LIM data relevant to future design activities.

147396 DA
LINEAR INDUCTION MOTOR ELECTRICAL BRAKING TEST
Powell, RB
AiResearch Manufacturing Company 2525 West 190th Street Torrance California 90509; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Apr 1976 Final Rpt. 115 pp
REPORT NO: 75-11969-Rev-1; FRA/ORD-76/264
CONTRACT NO: DOT-FR-40016; Contract
SUBFILE: NTIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 261851)
This report describes the electrical braking characteristics of a 2500-hp (at 250 mph) linear induction motor (LIM), which is used to propel and brake the LIM research vehicle. Three methods of electrical braking were investigated: ac dynamic braking, dc eddy current braking, and plugging. From the data acquired the following information was derived and is presented herein for each of the braking methods investigated: (1) LIM electrical braking characteristics in terms of braking force developed as a function of vehicle speed, with all data referred to a 2000-A primary

current, (2) powerplant characteristics, (3) the location and magnitude of the braking energy dissipated, and (4) power and control equipment requirements. Pertinent LIM design information is also included to enable independent investigators to correlate analytical predictions with the test data published herein.

145597 DA
A PRELIMINARY EVALUATION OF ELECTRICAL PROPULSION BY MEANS OF IRON-CORED SYNCHRONOUSLY OPERATING LINEAR MOTORS
Levi, E
Polytechnic Institute of New York 333 Jay Street Brooklyn New York 11201 Federal Railroad Administration Office of Research, Development and Demonstrations Washington D.C. 20590
Jan 1975 Tech. Rpt. 113 pp
REPORT NO: FRA-TR-76-128
CONTRACT NO: DOT-FR-30030; Contract
SUBFILE: NTIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 258437)
The report is a preliminary evaluation of the technical feasibility of using iron-cored, synchronously operating motors to propel ground transportation vehicles in the high cruise speed range. A second consideration is the possibility that the motor might also provide strong attractive and lateral forces. Three motor types, all realizable with passive track rails are investigated: (a) claw-pole synchronous motor, (b) homopolar inductor motor, and (c) heteropolar inductor motor. A rail clearance of 1.5 cm is specified. However, the effect of variations in this and other design parameters is also analyzed. All three types considered compare favorably with an equivalent single-sided induction motor, insofar as weight, efficiency, and power factor are concerned. The calculations are supported by analog simulation experiments.

143945 DA
EXPERIMENTS IN GUIDEWAY - LEVITATION VEHICLE INTERACTION DYNAMICS
Wilson, JF
Duke University Department of Civil Engineering Durham North Carolina 27706; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Jan 1976 Final Rpt. 88 pp
REPORT NO: FRA/OR&D-76/259
CONTRACT NO: DOT-FR-4-4098; Contract
SUBFILE: NTIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical InformatiService 5285 Port Royal Road Springfield Virginia 22161 (PB 257941)
This investigation involves the design and interpretation of laboratory-scale dynamic experiments of vehicles traversing multiple-span or cable-stayed guideways. The nondimensional responses of such systems, including critical span bending moments and vehicle heave accelerations, depend on the system parameters derived in Chapter 2. A point load 'vehicle' and two vehicles closely resembling advanced operational prototypes were designed and tested: the 150 mph Prototype Tracked Air Cushion Vehicle (PTACV), and the 300 mph Tracked Levitated Research Vehicle (TLRV). In Chapter 3, general experiments are designed, all based on these dimensionless system parameters and the capability of instrumentation and data processing minicomputers to measure and interpret response data. The remaining chapters include discussions and comparisons of response data for critical six and three-span guideway moments and for rms vehicle heave accelerations.

138087 DA
NINTH REPORT ON THE RAILROAD TECHNOLOGY PROGRAM
Federal Railroad Administration; 400 7th Street, SW; Washington; D.C.; 20590
Apr 1976 74 pp 42 Fig. 1App.
REPORT NO: FRA-OR&D 76-245
SUBFILE: RRIS; NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 253197)
A report on the Federal Railroad Administration's activities carried out under the High Speed Ground Transportation (HSGT) Act of 1965 as amended and extended, for the Secretary of Transportation to report annually to the President and the Congress on activities performed under the Act. This report covers the HSGT-funded research, development and demonstrations programs administered by the Office of Research and Development (OR&D) and

the Transportation Test Center (TTC) of the Federal Railroad Administration (FRA) in accordance with Section 10(a) of th Act and also encompasses related work performed under appropriations for advancing railroad technology and safety including the activities of the Transportation Test Center. The report covers program activities for the period October 1, 1974, to September 30, 1975. The report is designed to serve as a source of information for those having an interest in FRA's research, development and demonstration activities. A limited number of copies are made available to Committees of Congress, other Department of Transportation (DOT) organizations, academicians, prospective contractors, industry organizations and others who have an interest in FRA's R&D results.

137312 DA
MATRIX ANALYSIS OF LINEAR INDUCTION MACHINES
Elliott, DG
Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena Califonia 91103
Sep 1975 Final Rpt. 358 pp
REPORT NO: JPL-SP-43-24; FRA/ORD-75/77
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 254574)
A new method of analyses for linear induction machines, the matrix method, has been developed. The method handles linear induction motors, both single- and double-sided, and linear induction liquid metal pumps and generators, both flat and annular. The primary currents can be prescribed, calculated from prescribed phase voltages, or optimized for maximum machine efficiency. The matrix method incorporates accurate modeling of the magnetic field of the finite-length iron including the fields due to fringing, variable gap, slots, coils, and phase belts. The coils may have any arbitrary phase connections.

131038 DA
TRACKED LEVITATED RESEARCH VEHICLE. FINAL TECHNICAL REPORT: AEROPROPELLED
Magnani, E; Zapotowski, B
Grumman Aerospace Corporation; Bethpage, New York; 11714
Oct 1975 Final Rpt. 139 pp Figs.
REPORT NO: FRA-ORD&D 76-132
CONTRACT NO: DOT-FR-30041; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 249259)
The results of the 1973 aeropropelled tests of the Tracked Levitated Research Vehicle (TLRV) at the Transportation Test Center (TTC) are presented for the three basic suspension modes (Primary, Body/Chassis and Independent Cushion) at speeds up to 90 mph attained in the 3 mile guideway, which includes straight, transition to curve and superelevated segments. General vehicle and suspension characteristics are reviewed, and the system performance with respect to the air supply system, acoustics, vehicle speed and braking, cushion lift and ride comfort is discussed. Vehicle dynamic responses to perturbations installed in the guideway are compared with the results computed by the TLRV Dynamics Simulation Program.

129199 DA
CONCEPTUAL DESIGN AND ANALYSIS OF THE TRACKED MAGNETICALLY LEVITATED VEHICLE TECHNOLOGY PROGRAM (TMLV)--REPULSION SCHEME; VOLUME 1 - TECHNICAL STUDIES
Ford Motor Company; Scientific Research Staff; Dearborn, Michigan 48121
Feb 1975 Final Rpt. 380 pp Figs. 7 App.
REPORT NO: FRA-OR&D-75-21
CONTRACT NO: DOT-FR-40024; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 247931)
This report summarizes the studies of a program to establish the technology of magnetic suspension for ultimate use in a passenger-carrying high-speed ground transportation (HSGT) system - at speeds on the order of 134 m/s (300 mph). Magnetic Levitation (MAGLEV) is one of the advanced vehicle suspension concepts considered as alternatives to conventional transportation modes in the short-haul regime. These advanced systems have the potential of alleviating the heavy traffic congestion predicted for the highly populated regions of the U.S. in the 1985-1995 period. The national energy shortage has intensified the search for more energy-efficient and cost-effective transportation modes. This volume summarizes the analyses and designs which demonstrate the performance of the system including the

ability to meet the DOT ride quality standards on straight and level guideways as well as on curves and grade transitions. Conceptual designs and costs are shown for the vehicles, guideways, and the complete system. Various propulsion systems and guideway configurations are investigated, and a simple economic model is developed for the evaluation of MAGLEV systems on a cost per seat-mile or cost per passenger-mile basis. This project was sponsored by the Federal Railroad Administration, DOT.

129155 DA
CONCEPTUAL DESIGN AND ANALYSIS OF THE TRACKED MAGNETICALLY LEVITATED VEHICLE TECHNOLOGY PROGRAM (TMLV) - REPULSION SCHEME; EXECUTIVE SUMMARY
Ford Motor Company; Aeronutronic Division; Newport Beach,California 92663
Feb 1975 Final Rpt. 22 pp
REPORT NO: FRA-OR&D 75-21C
CONTRACT NO: DOT-FR-40024; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 247934)
This report is an Executive Summary of FRA report OR&D-75-21 which summarizes studies to establish the technology of repulsion magnetic suspension for ultimate use in a passenger carrying high speed ground transportation (HSGT) system - at speeds on the order of 134m/s (300 mph). A baseline revenue system is described in terms of vehicle/guideway configuration, system performance and cost. Levitation and guidance is provided by eight superconducting magnets. The magnetic fields interact with a pair of L-shaped aluminum guideway elements. Propulsion alternatives are discussed but this is the area where much work remains to be done to provide adequate performance and cost data for a final selection. This technology, designed to free ground transportation from the speed and noise limitations imposed by steel wheel on steel rail, will make possible the short trip times of planes with the huge capacity of trains. Both speed and capacity are essential to meet the demonstrated demand for rapid travel in the nation's congested corridors. Sponsorship was from Federal Railroad Administration, DOT.

126976 DA
ANALYSIS OF A COMBINED ATTRACTION-MAGLEV-PROPULSION SYSTEM FOR A HIGH SPEED VEHICLE
Muhlenberg, JD; Nene, VD
Mitre Corporation; Westgate Research Park; McLean; Virginia; 22101
Mar 1974 45 pp 32 Fig. 4 Tab. 9 Ref.
REPORT NO: FRA-75-61
CONTRACT NO: DOT-FR-30015; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 245189)
This document presents the results of a study of a combined levitation-propulsion system for a high speed ground transportation vehicle incorporating a single-sided linear induction motor as the levitation-propulsion unit. The system is first synthesized in accordance with design constraints and subsequently examined in detail. Time responses and rms values of various parameters of interest are calculated. The conclusion of this preliminary investigation is that such a system is feasible and deserves further study. Sponsored by FRA.

125890 DA
TRACKED LEVITATED RESEARCH VEHICLE PERIODIC TEST SUMMARY REPORT BODY/CHASSIS SUSPENSION AEROPROPELLED-SMOOTH GUIDEWAY
Fischer, G; Zapotowski, B
Grumman Aerospace Corporation; Bethpage, New York 11714
Aug 1974 Test Sum. 157 pp Figs. Tabs. 5 Ref.
REPORT NO: FRA-OR&D 75-97
CONTRACT NO: DOT-FR-30041; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 243987)
The results of the first tests of the Tracked Levitated Research Vehicle (TLRV) in the guideway at the High Speed Ground Test Center (HSGTC) are presented for the Body/Chassis Suspension mode. Vehicle dynamic response behavior and secondary suspension characteristics are discussed. Braking performance is discussed for the speed range from 0 to 78 mph. See also PB-244281/2ST

125889 DA
TRACKED LEVITATED RESEARCH VEHICLE BODY/CHASSIS SUSPENSION IN PERTURBED GUIDEWAY AEROPROPELLED
Zapotowski, B; Bauer, B; Magnani, E
Grumman Aerospace Corporation; Bethpage, New York 11714
Nov 1974 Test Sum. 117 pp Figs. Tabs. 5 Ref.
REPORT NO: FRA-OR&D-75-98
CONTRACT NO: DOT-FR-30041; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 244282/0)
The results of the first tests of the Tracked Levitated Research Vehicle (TLRV) in the Body/Chassis Suspension mode over the perturbed guideway at the High Speed Ground Test Center (HSGTC) are presented. Vehicle dynamic response behavior is discussed for the speed range from 0 to 70 mph, including comparisons of test data with the responses computed by the TLRV Dynamics Simulation Program. Sponsored by DOT Federal Railroad Administration.

099181 DA
TRACKED LEVITATED RESEARCH VEHICLE DYNAMICS SIMULATION PROGRAM USER'S MANUAL. ADDENDUM
Zapotowski, B
Grumman Aerospace Corporation; Research Department;Bethpage,New York 11714
Feb 1975 95 pp Figs. Tabs. 1 Ref.
REPORT NO: FRA-OR&D 75-78
CONTRACT NO: DOT-FR-30041; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 242907)
A digital computer program was generated to evaluate the dynamic characteristics of the Tracked Levitated Research Vehicle. Additional programming and new input data requirements are described in this addendum that enable the reduction and plotting of vehicle test data stored on magnetic tape concurrently with simulated responses. The changes incorporate inproved theory and algorithmas and permit more comprehensive theoretical dynamic analyses to be performed. This manual is an addendum to the Tracked Air Cushion Research Vehicle - Dynamics Simulation Program User's Manual, Department of Transportation Report FRA-RT-73-19, October 1972, NTIS Accession No. PB 219 984/2. This program was sponsored by Federal Railroad Administration's Office of Research and Development.

099174 DA
COMPARISON OF TWO HSGT MAGNETIC SUSPENSION SYSTEMS (ATTRACTION)
Borcherts, RH
Ford Motor Company; Scientific Research Staff, P.O. Box 2053; Dearborn, Michigan 48121
Feb 1975 Final Rpt. 13 pp 5 Fig. 11 Ref.
REPORT NO: FRA-OR&D 75-75
CONTRACT NO: DOT-FR-10026; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 244226)
Two alternate attraction magnetic suspension systems are compared on a magnetic performance basis as well as on their lift-to-weight (L/W) capabilities. On an equal current basis, the lower reluctance, flat track configuration has higher lift force and better L/W than the U shaped track configuration with its larger leakage flux. With equal magnetization (unequal currents) and low guidance forces, the U shaped track has a higher L/W ratio, but both attraction systems suffer from low L/W when all elements of the suspension system are considered. This report supplements NTIS PB238773 "Parameter Optimization Studies of Magnetic Suspensions for High Speed Ground Transportation" (Ford Motor Co.) April, 1974. Prepared for DOT, Federal Railroad Administration.

095721 DA
ANALYSIS AND SIMULATION OF VEHICLE/GUIDEWAY INTERACTIONS WITH APPLICATION TO A TRACKED AIR CUSHION VEHICLE
Ravera, RJ; Anderes, JR
Mitre Corporation; 1820 Dolley Madison Boulevard; McLean; Virginia; 22101
Feb 1975 Tech. Rpt. 102 pp Figs. 20 Ref. Apps.
REPORT NO: FRA-ORD & D-75-38
CONTRACT NO: DOT-FR-30015; Contract

SUBFILE: HRIS; NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 242014)
Several analytical methods for investigating the problem of vehicle/guideway dynamic interactions are presented. These methods include several digital programs, each tailored to solve a particular aspect of the vehicle/guideway problem. Also included are computerized frequency domain methods for rapid estimation of system sensitivity to principal parameters and for use in selecting candidate guideway parameters. The major tool is the full scale vehicle/guideway dynamic interaction simulation, TRAVSIM, which includes coupled vehicle/guideway dynamics, independently generated guideway roughness profiles, and data processing for obtaining vehicle output data in the various ride quality formats. An example of the use of these methods to analyze the effects of guideway roughness and flexibility on a specific vehicle is illustrated. Roughness parameters are given in terms readily understandable to guideway contractors and include camber, pier settlement, pier survey error and surface finish. Results show that it is possible to vary roughness and cross section parameters and tolerances while achieving equivalent vehicle performance. Therefore, it seems possible to allow the guideway contractor to select the least costly set of tolerances to achieve the specified ride quality.

094414 DA
TRACKED LEVITATED RESEARCH VEHICLE PERIODIC TEST SUMMARY REPORT INDEPENDENT CUSHION SUSPENSION IN PERTURBED GUIDEWAY. AEROPROPELLED
Bauer, E; Magnani, E; Zapotowski, B
Grumman Aerospace Corporation; Research Dept.;Bethpage, New York 11714
Sep 1975 Summ Rpt. 247 pp
REPORT NO: PMT-B4-R75-2; FRA/ORD/D-76-131
CONTRACT NO: DOT-FR-30041; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 249258)
The results of the first tests of the Tracked Levitated Research Vehicle (TLRV) in the Independent Cushion Suspension mode over the perturbed guideway at the Transportation Test Center (TTC) are presented. Vehicle dynamic response behavior is discussed for the speed range from 0 to 90 mph, including comparisons of test data with the responses computed using the TLRV Dynamics Simulation Program. See also PB-244 282.

094413 DA
TRACKED LEVITATED RESEARCH VEHICLE PERIODIC TEST SUMMARY REPORT INDEPENDENT CUSHION SUSPENSION AEROPROPELLED-SMOOTH GUIDEWAY
Fischer, G; Zetkov, G
Grumman Aerospace Corporation; Research Dept; Bethpage, New York 11714
Aug 1975 Summ Rpt. 120 pp
REPORT NO: PMT-B4-R75-1; FRA/ORD/D-76-130
CONTRACT NO: DOT-FR-30041; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 249126)
The results of the first tests of the aeropropelled Tracked Levitated Research Vehicle (TLRV) in the smooth guideway at the Transportation Test Center (TTC) are presented for the TLRV in the Independent Cushion Suspension mode. Vehicle and cushion dynamic response behavior are discussed. Braking performance is presented for the speed range from 0 to 90 mph. See also PB-249 259.

094116 DA
CONCEPTUAL DESIGN AND ANALYSIS OF THE TRACKED MAGNETICALLY LEVITATED VEHICLE TECHNOLOGY PROGRAM (TMLV). REPULSION SCHEME. VOLUME III. APPENDIX G. 5 DOF COMPUTER PROGRAM
Philco-Ford Corporation, Aeronutronic Division; Newport Beach, California 92663; Ford Motor Company, Scientific Research Staff; Dearborn, Michigan 48127; Federal Railroad Adm., 400 7th Street, SW; Washington D.C. 20590
Feb 1975 Final Rpt. 93 pp
REPORT NO: PF-TMLV-TR-0037B; FRA/ORD-75-21B
CONTRACT NO: DOT-FR-40024; Contract
SUBFILE: NTIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 247933)
This report summarizes the studies of a program to establish the technology of magnetic suspension for ultimate use in a passenger-carrying high-speed ground transportation (HSGT) system - at speeds on the order of

134 m/s (300 mph). Magnetic Levitation (MAGLEV) is one of the advanced vehicle suspension concepts considered as alternatives to conventional transportation modes in the short-haul regime. This third volume contains the computer programs for the solution of the equations of motion for 5 degrees-of-freedom, and a summary of the analytical background. These programs provide the capability for performing stability analyses of magnetically levitated vehicles, and for evaluating vehicle response and ride quality characteristics for operation over guideways with irregularities. Each program is listed along with a sample run. The programs are written in BASIC language for use on time-sharing systems. Prepared in cooperation with Ford Motor Co., Dearborn, Mich. Scientific Research Staff. Paper copy also available in set of 4 reports as PB-247 930-SET.

094115 DA
CONCEPTUAL DESIGN AND ANALYSIS OF THE TRACKED MAGNETICALLY LEVITATED VEHICLE TECHNOLOGY PROGRAM (TMLV). REPULSION SCHEME. VOLUME II. APPENDICES A - F
Philco-Ford Corporation, Aeronutronic Division; Newport Beach, California 92663; Federal Railroad Administration, Office of Research and Development; Washington, D.C. 20590
Feb 1975 Final Rpt. 142 pp
REPORT NO: PF-TMLV-TR-0037A; FRA/ORD-75-21A
CONTRACT NO: DOT-FR-40024; Contract
SUBFILE: NTIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 247932)
This report summarizes the studies of a program to establish the technology of magnetic suspension for ultimate use in a passenger-carrying high-speed ground transportation (HSGT) system - at speeds on the order of 134 m/s (300 mph). Magnetic Levitation (MAGLEV) is one of the advanced vehicle suspension concepts considered as alternatives to conventional transportation modes in the short-haul regime. This volume presents some details of the mathematical analysis associated with the MAGLEV vehicle dynamics and control (i.e., ride quality) in Appendices A through D; the noise or acoustic characteristics associated with the baseline Hamilton Standard Q-fan air propulsion system (Appendix E); and the Raytheon final report for the linear synchronous motor (LSM) studies (Appendix F). Prepared in cooperation with Ford Motor Co., Dearborn, Mich. Scientific Research Staff. Paper copy also available in set of 4 reports as PB-247 930-SET, PC$22.00.

090185 DA
CABLE-STAYED GUIDEWAY. ANALYSES AND DYNAMIC MODEL TESTS
Whitelaw, RL; Szeless, AG; Counts, J; Garst, DA
Virginia Polytechnic Institute & State University College of Engineering Blacksburg Virginia 24061; Federal Railroad Administration Office of Research and Development Washington D.C. 20590
Apr 1974 Final Rpt. 239 pp
REPORT NO: FRA/ORD/D-74-18
CONTRACT NO: DOT-FR-3004; Contract
SUBFILE: NTIS; HRIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 238915)
This report presents the results of scale model tests and parametric structural analyses which were performed in support of a conceptual investigation of cable-stayed guideways for suspended vehicle systems (SVS). The SVS concept would use high speed ground transportation (HSGT) vehicles suspended from an overhead guideway and which could achieve large cabin bank angles for high speed turns. This cabin bank mechanism allows the SVS to maintain a high speed, even when the guideway is collocated with an existing freeway or railroad with relatively tight turn radii. The possibility of collocating the SVS guideway is further improved by the use of cable-stayed guideways with spans of 200 feet or greater. This report describes the static and dynamic tests of a 1:24 scale model of a 250-foot span cable stayed guideway which was designed for a conceptual SVS.

090174 DA
PARAMETER OPTIMIZATION STUDIES OF MAGNETIC SUSPENSIONS FOR HIGH SPEED GROUND TRANSPORTATION
Borcherts, RH; Davis, LC; Wan, CC; Mohdulla, AU; Reitz, JR
Ford Motor Company, 23400 Michigan Avenue; Dearborn, Michigan 48127; Federal Railroad Administration, Office of Research and Development; Washington, D.C. 20590

Apr 1974 Final Rpt. 159 pp 74 Fig. Tabs. 15 Ref. 2 App.
REPORT NO: FRA-ORD&D-74-42
CONTRACT NO: DOT-FR-10026; Contract
SUBFILE: NTIS; HRIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 238773)

The study investigates efficient, cost-effective methods of high speed ground transportation for intercity travel. Previous aspects of the program have demonstrated the technical feasibility of two types of magnetic suspensions (the attractive-force, and the repulsive-force suspensions) for such applications, and have developed a baseline design for a TMLRV (tracked magnetically levitated research vehicle). The attractive force suspension considers the development of a mathematical model which predicts the magnetic behavior of the magnet-rail system for high speed, and a parameter optimaization of the magnet. The repulsive-force suspension examines various track geometries to see if the amount of aluminum in the track could be reduced without loss of performance. Experimental studies have been carried out to support the analytical aspects of the program. Related reports include NTIS PB 223237 "Preliminary Design Studies of Magnetic Suspensions for High Speed Ground Transportation" (Ford Motor Co.) and FRA-ORD&D-74-41 "An Evaluation of the Dynamics of a Magnetically Levitated Vehicle" (SRI).

080883 DA

DESIGN, DEVELOPMENT AND TEST OF A WAYSIDE POWER DISTRIBUTION AND COLLECTION SYSTEM FOR THE TRACKED LEVITATED RESEARCH VEHICLE
Webster, JO; Shapiro, H; Guenther, C; Kalman, G; Clemence, J; Mitchel, S
AiResearch Manufacturing Company; 2525 West 190th Street; Torrance; California; 90509
Apr 1974 Final Rpt. 200 pp Figs. Tabs.
REPORT NO: FRA/ORD&D74-25
CONTRACT NO: DOT-FR-10002; Contract
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 238 910)

This document presents test activity description and results of the wayside power distribution and collection system designed for the TLRV, a high-speed ground transportation vehicle. The system was assembled at the U.S. Navy testing grounds, China Lake, California to prove the design concept and feasibility of transferring high-electrical power between rail and collector brushes at elevated speeds while subjected to prevailing environmental conditions. With minor modifications, the initial design conformed to specified requirements up to speeds in excess of 300 mph. Analysis of the rail configuration and test results indicated that distance between the wayside rail supports could be doubled (25 ft) lessening by half the number of supports required to maintain the rail's alignment integrity at design speeds. Installation of the wayside rail system at HSGTC, Pueblo, Colorado will be constructed using the 25 ft span configuration. This document was prepared for the Office of High Speed Ground Transportation, Federal Railroad Administration, DOT.

080781 DA

AERODYNAMICS OF VEHICLES IN FINITE LENGTH TUBES
Hammitt, AG
TRW Transportation and Environmental Operations; One Space Park; Redondo Beach; California; 90278
Apr 1974 Final Rpt. 86 p. 33 Fig. 2 Tab. 11 Ref. 3 App.
REPORT NO: FRA-ORD&D-74-10
CONTRACT NO: DOT-FR-30004; Contract
SUBFILE: HRIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161 (PB 236692)

High speed vehicles may operate in tunnels or tubes to minimize impact on the surrounding environment. Operation in tunnels or tubes minimizes the impact of surface obstacles, high noise levels, weather constraints and street congestion in metropolitan areas. The performance of these vehicles is significantly affected by the aerodynamics and needs to be understood. The aerodynamics of vehicles traveling through tubes are significantly affected by the constraints of the tube wall and the relative size (blockage ratio) of the vehicle. Steady flow conditions are reached only after long travel times. In this report, the flow created by vehicle travel in a tube is analyzed using numerical integration of the unsteady flow equations. Steady state conditions are rarely obtained for closed-end tubes up to several hundred miles in length. Solutions are presented for various blockage ratio vehicles with choked and unchoked flow conditions about them. Various tube lengths are also considered. The solution for a doubly infinite tube is found to be approaching the asymptotic long time solution. This document was prepared for the Federal Railroad Administration, DOT.

072689 DA
AN EVALUATION OF THE DYNAMICS OF A MAGNETICALLY LEVITATED VEHICLE
Coffey, HT; Colton, JD (Solinsky, JC; Woodbury, JR)
Stanford Research Institute 333 Ravenswood Avenue Menlo Park California 94025 No. 1080
Mar 1974 Final Rpt 160 pp 75 Fig. 4 Tab. 8 Ref. 2 App.
REPORT NO: FRA-ORD&D-74-41
CONTRACT NO: DOT-FR-10001; Contract
SUBFILE: HRIS; NTIS; RRIS; UMTRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 236671)
An analytical and experimental evaluation was made of the stability and dynamic characteristics of a small scale magnetically levitated vehicle. The vehicle was levitated over a variety of guideway perturbations in an attempt at stimulating unstable modes of oscillation. No instabilities developed in the five degrees of freedom measured using either passive or active damping. The analytical model was used to simulate the observed motions of the vehicle using a computer. Reasonable agreement was found although more damping was observed than was simulated using the model. This work was performed as a part of the Federal Railroad Administration's program of research and development on high speed ground transportation for use in intercity passenger service. Related reports are NTIS PB-221696, Study of a Magnetically Levitated Vehicle, and NTIS PB-210505, The Feasibility of Magnetically Levitating High Speed Ground Vehicles. Research was sponsored by Federal Railroad Administration, office of Research Development and Demonstration.

072688 DA
INVESTIGATION OF REDUCED COST GUIDEWAY DESIGNS FOR THE TRACKED AIR CUSHION RESEARCH VEHICLE. PART A
Birkeland, PW; McCullough, BF; Meisenholder, SG; Oye, J
TRW Systems Group; One Space Park; Redondo Beach; California; 90278
Dec 1972 230 pp Figs. 7 Tab. 4 App.
REPORT NO: FRA-ORD&D-74-55
CONTRACT NO: DOT-TSC-442; Contract
SUBFILE: RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 235123)
A study was made of alternate low cost guideway design concepts for the 300 mph Tracked Air Cushion Research Vehicle which will be tested at the DOT High Speed Ground Test Center at Pueblo, Colorado. The proposed concepts are both within present state of the art, and are designed to take maximum advantage of the existing technology used in the highway construction industry. The chief requirements are low construction cost and safe operation of vehicles at speeds up to 300 miles per hour. The various guideway design constraints imposed by the vehicle are discussed and used to evolve the preferred design concepts. The requirement for acceptable passenger ride comfort is interpreted in terms of guideway surface smoothness considerations by means of a probabilistic analysis of vehicle response. Various construction techniques are investigated and cost estimates are presented for each of the preferred concepts. The costs of the two preferred guideway design concepts are compared to the cost of the existing design which is being used for the initial construction phases at HSGTC. The sensitivity of the construction cost to certain guideway design features is discussed. Estimates showed that the tow preferred concepts should cost 30 - 50% less than the existing design. Research was done jointly by ABAM Engineers and TRW Systems. The work was sponsored by the Department of Transportation, Transportation Systems Center, Cambridge, Massachusetts.

071743 DA
HIGH-SPEED GROUND TRANSPORTATION SYSTEMS ENGINEERING STUDY. SUSPENDED MONORAIL DYNAMIC STUDY
Dulock, VA; Kreisberg, HN; Plotkin, SE
TRW Systems Group; Washington; D.C.
Dec 1969 Final Rpt. 89 pp
REPORT NO: FRA-RT-70-45
CONTRACT NO: C-353-66; Contract
SUBFILE: RRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 194406)

The report documents the results of work directed towards examining the potential for high speed operation of the Safege suspended monorail configuration. A three-dimensional multi-degree-of-freedom dynamic model of the vehicle is developed and tested under varying ride conditions. Systems parameters, such as cabin weight, damping rates, spring constants, etc., are varied in order to gauge their individual and combined effects on the vehicle's ability to meet specified ride comfort standards. A configuration capable of maintaining these standards at velocities of 150 mph is documented. (Author) Report on High-Speed Ground Transportation Systems Engineering Study.

056900 DA

HSB: STUDY OF HIGH SPEED INTERCITY SURFACE TRANSPORTATION SYSTEM FOR GERMANY. VOLUME III. ATTACHMENT 7

Neuber, HD; Pennekamp, A; Rothermel, VH

Federal Railroad Administration; Office of Research and Development; Washington; D.C.; 20590

Rpt 436p

REPORT NO: FRA-ORD/D-74-26C

SUBFILE: NTIS; RRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 230460)

Volume three of a six volume study of rapid transit planning for West German intercity rail systems deals with wheel rail interactions, passenger comfort, magnetic carrying and guidance or suspension systems, pneumatic supporting and guidance systems, dynamics of air cushion suspensions, gas turbines, diesel motors, power transmission, electrical energy supply and transmission, rotating electrical drives, brakes, and aerodynamic propulsion. Technical trans. of Hochleistungs-Schnellbahn Studiengesellschaft mbH, Ottobrunn. Report (West Germany). Paper copy also available from NTIS $37.00/set of 6 reports as PB-230 457-T-SET.

039302 DA

SINGLE-SIDED LINEAR INDUCTION MOTOR (SLIM); A STUDY OF THRUST AND LATERAL FORCES

Lipkis, RS; Wang, TC

TRW Systems Group; Washington Operations; McLean; Virginia

Jun 1971 Final Rpt 127 pp

REPORT NO: 06818-W032-R0-00; FRA-RT-72-25

CONTRACT NO: DOT-C-353-66; Contract

SUBFILE: NTIS; RRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 205029)

The report represents a steady-state linear analysis of single-sided linear induction motors. Electromagnetic field equations are used to describe the magnetic field distribution across the air gap and inside the reaction rail, from which the induced current density and force vectors are determined. The tangential component of the magnetic field and the secondary current result in a body force perpendicular to the stator surface. Analytical expressions for this lateral force and the thrust parallel to the stator surface are derived. Special attention is given to the magnitude of the lateral force under various design conditions. It appears that a SLIM can be used for both the propulsion and the levitation of a high-speed vehicle for ground transportation. (Author)

039298 DA

THE SINGLE-SIDED LIM WITH SATURATED BACK IRON

Dukowicz, JK

Mitre Corporation; McLean; Virginia

Jan 1972 Final Rpt 62 pp

REPORT NO: MTR-6094; FRA-RT-72-28

CONTRACT NO: DOT-FR-7-35248; Contract

SUBFILE: NTIS; RRIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 207327)

For reasons of economy, the single-sided Linear Induction Motor should be designed to operate with saturated reaction rail back iron. The report discusses the effects on back iron saturation on the performance of the motor, and formulates a technique for determining the minimum thickness of iron required. As a specific example, the TACRV motor is analyzed in detail. It is found that a laminated iron backing of only 3/4 inch thickness is required. (Author)

039296 DA
TRACKED AIR CUSHION RESEARCH VEHICLE VEHICLE/GUIDEWAY DYNAMIC ANALYSIS
Pulgrano, L
Grumman Aerospace Corporation; Bethpage; New York
Mar 1971 Design Rpt 247 pp
REPORT NO: PMT-B4-R71-07; FRA-RT-72-30
CONTRACT NO: DOT-FR-00005; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 209511)

A primary test objective of the TACRV research program is the evaluation of dynamic performance. A basic measure of dynamic performance is ride quality, which can be defined in terms of acceleration on the body of the vehicle. The major objectives of the vehicle/guideway dynamic analyses were to provide information needed for the vehicle suspension and guideway design, to provide assurance of stable dynamic characteristics up to maximum speed, and to estimate ride quality. (Author)

039293 DA
UNSTEADY FLOW IN TUBES AND TUNNELS
Brown, FT; Knebel, G; Margolis, D
Massachusetts Institute of Technology; Engineering Projects Laboratory; Cambridge; Massachusetts
Aug 1971 Final Rpt 327 pp
REPORT NO: DSR-76107-4; FRA-RT-72-22
CONTRACT NO: DOT-C-85-65; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 204584)

A theory is presented for the attenuation and dispersion of small sinusoidal waves superimposed on gross turbulent flow in cylindrical tubes. Three frequency bands are distinguished: a low-frequency band in which a constant-inertance-resistance-compliance model applies, a high-frequency band in which a time-invariant-eddy-viscosity model applies, and an intermediate transition band for which no complete theory is given. Experiment corroborates the theory, and reveals dramatic resonances in the transistion band associated with nonequilibrium turbulence. A quasi method of characteristics is presented in general and in detail for the case of fluid transients with history-dependent properties such as occur at intermediate and high frequencies. Historetic weighting functions are the key to the method, and are found for laminar flow and several different turbulent flows. Results are extended to include the effects of heat transfer in a perfect gas contained by isothermal walls.

039292 DA
AUTOMATED GUIDEWAY TRANSPORTATION BETWEEN AND WITHIN CITIES
Wilson, DG
Massachusetts Institute of Technology; Urban Systems Laboratory; Cambridge; Massachusetts
Feb 1971 Final Rpt 251 pp
REPORT NO: FRA-RT-72-14
CONTRACT NO: DOT-C-85-65; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 206269)

The general characteristics and specifications of automated guideway transportation, defined as systems in which individual vehicles travel at close spacings under full lateral and longitudinal control, and in which all stations off line, have been studied. The areas examined include travel demands; costs; performance requirements; guideway spacing; dual-mode use; safety; reliability and emergency procedures; control and communications systems; information organization and transfer; network and terminal design; and guideway structures. The potential of guideways for providing inter-city movement, predominantly of miscellaneous freight, considered.

039291 DA
SYNCHRONOUS LONGITUDINAL GUIDANCE (SLG) ALLOCATION ALGORITHM EFFECTIVENESS STUDY
Kan, IF; Lukas, MP; Arquette, LK; Boyd, RK
TRW Systems Group; Washington Operations; McLean; Virginia
Jun 1971 Final Rpt 76 pp
REPORT NO: 06818-W033-RO-00; FRA-RT-72-20
CONTRACT NO: DOT-C-353-66; Contract

SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 203499)

A previously developed algorithm for allocating guideway space in a deterministic automated transportation network has already been verified as being a useful traffic management technique. This report investigates the algorithm's effectiveness under a variety of network operating policies and demand conditions. The report develops a methodology for the evaluation of algorithm effectiveness, evaluates the algorithm's effectiveness in representative transportation network traffic conditions which may degrade effectiveness. Algorithm operation, as determined by computer simulation, is defined to be effective if it produces traffic patterns which match those obtained using linear programming optimization techniques. It was concluded that the algorithm is a useful, flexible and effective tool in controlling traffic patterns in a deterministic transportation system. (Author)

039290 DA
DYNAMIC RESPONSE TESTS OF AN AIR CUSHION SUSPENSION SYSTEM FOR THE LINEAR INDUCTION MOTOR (LIM) OF THE TRACKED AIR CUSHION RESEARCH VEHICLE(TACRV)
Meisenholder, SG; Graham, HR; Birchill, J
TRW Systems Group; Redondo Beach; California
Jul 1971 Final Rpt 293 pp
REPORT NO: 17617-6003-R0-00; FRA-RT-72-24
CONTRACT NO: DOT-FR-00044; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 204440)

The report presents the results of a test program to determine the dynamic response characteristics of an air cushion suspension system. The air cushion and secondary suspension are designed for the support and guidance of the linear induction motor (LIM) on the 300 mph Tracked Air Cushion Research Vehicle (TACRV). The tests simulate the motion of the suspension system on the TACRV moving over a guideway with sinusoidal surface irregularities. The test variables included oscillatory excitation amplitude, air supply system admittance, air cushion skirt configuration and reaction rail flexibility. Test results are compared to theoretical response predictions for both the LIM support and guidance systems. (Author)

039285 DA
AN EXPERIMENTAL STUDY OF A FLAT-BOTTOMED SEMI-CIRCULAR WING IN VERY CLOSE PROXIMITY TO THE GROUND
Pepin, JN; Widnall, SE; Barrows, TM
Massachusetts Institute of Technology; Fluid Dynamics Research Laboratory; Cambridge; Massachusetts
Sep 1971 Final Rpt 27 pp
REPORT NO: FRA-RT-72-23
CONTRACT NO: DOT-C-85-65; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 203602)

An experimental investigation of a semicircular wing flying very close to a solid boundary is performed to verify recent analytical results. Comparison is made between first order theory and data through plots of lift coefficient versus angle of attack for various clearances. Reasonable agreement is obtained for these cases within the limitations of the theory. Lift/drag ratio plots are also presented which show the potential of such a technique for support vehicles. A brief outline of the theoretical development is also included to give some insight into the type of analysis which was used.

039284 DA
SUMMARY OF RESEARCH AT MIT ON TECHNOLOGY FOR HIGH SPEED GROUND TRANSPORT-SUMMARY REPORT
Seifert, WW
Massachusetts Institute of Technology; Cambridge; Massachusetts
May 1971 Summ Rpt 80 pp
REPORT NO: FRA-RT-72-18
CONTRACT NO: DOT-C-85-65; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 202809)

The work includes: Vehicle suspension systems, vehicles and tube aerodynamics, rock fracture and mechanics, settlement and leave analysis, and automated guideways. (Author) See also Progress rept. dated 31 Aug 70, PB-198 015.

039282 DA
AIR CUSHION SUPPORT FOR EVACUATED TUBE SYSTEM VEHICLES
Fraize, WE
Mitre Corporation; McLean; Virginia
Sep 1971 Tech Rpt 22 pp
REPORT NO: FRA-RT-72-21
CONTRACT NO: C-7-35248; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 203569)
The practicality of a plenum-type air cushion suspension for evacuated tube system (TVS) vehicles is examined from the standpoint of ideal air cushion/vehicle characteristics (power, mass flow, self-support velocity, cushion temperature), the compressor design, and the compressor efficiency under low pressure operating conditions. For a representative 100,000 lb TVS vehicle, an air cushion suspension is shown to be practical from all standpoints, providing tube pressure is no less than .015 atm, and the cushion gap is of the order of .01 ft. The method of analysis is presented graphically in a manner readily permitting analysis of other TVS configurations. (Author)

039278 DA
TRACKED AIR CUSHION RESEARCH VEHICLE. VEHICLE PERFORMANCE
Savatteri, C; Helgesen, J
Grumman Aerospace Corporation; Bethpage; New York
Mar 1971 38 pp
REPORT NO: PMT-B4-R71-02; FRA-RT-72-34
CONTRACT NO: DOT-FR-00005; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 209443)
The performance of the TACRV in terms of speed, acceleration and deceleration is discussed in this report and the range of cushion operating gaps is summarized. There performance items are presented for the vehicle operating at the Department of Transportation High Speed Ground Test Center at Pueblo, Colorado (5000 ft altitude). (Author)

039276 DA
4 GHZ DIELECTRIC WAVEGUIDE COMMUNICATION LINE
Abele, M; Medecki, H
General Applied Science Laboratories, Incorporated; Westbury; New York
Nov 1971 Final Rpt 59 pp
REPORT NO: GASL-TR-762; FRA-RT-72-29
CONTRACT NO: DOT-FR-10030; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 208474)
The report presents the study of a 4 GHz dielectric waveguide communication line. Section 2 of the report presents the conclusions and the recommendations for an operational system. Sections 3 and 4 present the details of the technical work. (Author)

039227 DA
DYNAMICS OF INDEPENDENTLY ROTATING WHEEL SYSTEMS
Kaplan, A; Short, SA
TRW Systems Group; Redondo Beach; California
Jul 1970 Final Rpt 74 pp
REPORT NO: 06818-6045-RO-00; FRA-RT-71-47
CONTRACT NO: DOT-C-353-66; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 194000)
The report presents the results of an analysis of the dynamics of individually rotating wheel systems for use on high speed rail systems such as the Tube Vehicle System (TVS). The objective of this system is to remove the hunting stability problems of conventional rail-wheel systems and thus improve the vehicle ride comfort and safety. The analysis indicates that the use of independently rotating wheel systems eliminates the standard hunting instability, but it introduces a lightly damped but stable oscillation of its own. However, by increasing the yaw stiffness, the

frequency of this oscillation can be moved beyond the low point in the human vibration tolerance limit. When this is done, the ride response is improved over that for a conventional integral wheel system. (Author) High-Speed Ground Transportation Systems Engineering Study.

039226 DA
LIM GUIDANCE CONTROL SYSTEMS
Muhlenberg, JD
Mitre Corporation; McLean; Virginia
Jun 1970 175 pp
REPORT NO: MTR-4136-Rev-1; FRA-RT-71-46
CONTRACT NO: DOT-7-35248; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 193933)
The feasibility of control systems for positioning the LIM with respect to the reaction rail without physical contact is examined. Preliminary design analyses are made for several representative systems. Systems for use with both a ferrous or composite reaction rail and a nonferrous rail are examined and comparisons of system performance are made. A comprehensive performance criterion is developed. Recommendations for future investigations are made. (Author)

039224 DA
TUBE VEHICLE SYSTEM (TVS) TECHNOLOGY REVIEW
Trzaskoma, WP
Mitre Corporation; McLean; Virginia
Jul 1970 Intrm Rpt 65 pp
REPORT NO: M70-4; FRA-RT-71-44
CONTRACT NO: DOT-7-35248; Contract
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 193451)
Contents: Description of tube vehicle systems; OHSGT research to date; Research not sponsored by OHSGT.

039083 DA
LITERATURE SURVEY ON THE COMMAND AND CONTROL OF HIGH-SPEED GROUND ORIENTED TRANSPORTATION SYSTEMS
Hughes Aircraft Company; Transportation Research Project Office; Fullerton; California
Mar 1966 56 pp
REPORT NO: FR-66-11-65
SUBFILE: NTIS; RRIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22151 (PB 170561)
Revision of FR65-11-281.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA-WA-06-0014-85-1	PB 86-188646	

4. Title and Subtitle	5. Report Date
Integrated Magnetic Propulsion and Suspension Top Suspended Dynamic Test Report	February 1985
	6. Performing Organization Code
7. Author(s) George Ecker, R. G. Gilliland, G. W. Pearson	8. Performing Organization Report No.
9. Performing Organization Name and Address Automated Transportation Systems Boeing Aerospace Company P.O. Box 3999 Seattle, WA 98124	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DTUM60-80-C-71009
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S.W. Washington, D. C. 20590	13. Type of Report and Period Covered Test Report
	14. Sponsoring Agency Code URT-12

15. Supplementary Notes

16. Abstract

This report describes the tests performed on a full scale magnetically suspended vehicle using the Integrated Magnetic Propulsion and Suspension (IMPS) system. The IMPS uses the same Linear Induction Motor (LIM) to provide both suspension and propulsion forces and offers significant advantages compared to conventional technologies.

The tests were performed on a 27.5 m (90 ft) long test track in a top suspended configuration. The tests consisted of the Lift and Thrust Mapping Test, the Far Field Flux survey Test and the Low Speed Dynamic Test.

The test results indicate good correlation between predicted and actual performance. The tests also showed the ability of the system to provide the required lift and thrust to operate the full weight vehicle, to maintain proper air gap for operation and to have acceptable ride comfort. The tests also show that the magnetic flux is confined to the immediate vicinity of the motor.

The potential for use as a public transportation system was clearly shown by the data collected, by observing the system operation and experience in the design and the handling of the vehicle.

17. Key Words	18. Distribution Statement
Magnetic Suspension, Linear Induction Motor, Lift, Thrust, Magnetic Flux, Power Conditioning, Variable Frequency, Variable Voltage, Public Transportation	Available to the public through the National Technical Information Service Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	97	

Technical Report Documentation Page

1. Report No. UMTA-WA-06-0014-85-2	2. Government Accession No. PB 86 188653	3. Recipient's Catalog No.
4. Title and Subtitle Integrated Magnetic Propulsion and Suspension Hover Test Report		5. Report Date March 1985
		6. Performing Organization Code
7. Author(s) R. G. Gilliland and G. W. Pearson		8. Performing Organization Report No.
9. Performing Organization Name and Address Boeing Aerospace Company (A Division of the Boeing Co.) Automated Transportation Systems P.O. Box 3999 Seattle, WA 98124		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DTUM60-80-C-71009
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S.W. Washington, D. C. 20590		13. Type of Report and Period Covered Test Report June 1983 through March 1984
		14. Sponsoring Agency Code URT-12

15. Supplementary Notes

16. Abstract

The Hover Test consisted of two parts. Open loop tests were run for a check-out of the PCU's dc offset and phase balance, and to obtain open loop transfer functions of the control system when closed loop operation was impossible owing to system instability. Open loop tests were also run to measure LIM performance against predicted performance for flux density levels, temperature rise, and power consumption.

Closed loop tests were run to provide a means of optimizing control system gain settings, once stable operation was attained and to fine-tune the dc offset and phase balance of the PCU's for minimum disturbance at motor frequency and at twice motor frequency, respectively. The optimum settings, those that provided predicted response to heave and pitch step input signals while maintaining quiet operation, are reported.

17. Key Words Closed Loop, Control System Linear Induction Motor (LIM), Magnetic Levitation (Hover), Open Loop, Phase Balance, Power Conditioning Unit (PCU)	18. Distribution Statement Available to the public through the National Technical Information Service Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	92	

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Technical Report Documentation Page

1. Report No.
UMTA-WA-0014-86-1

2. Government Accession No.
PB87-171591

3. Recipient's Catalog No.

4. Title and Subtitle
Linear Synchronous Unipolar Motor (LSUM) Development Report

5. Report Date
October 1986

6. Performing Organization Code

8. Performing Organization Report No.

7. Author(s)
R.G. Gilliland and G.W. Pearson

9. Performing Organization Name and Address
Automated Transportation Systems
Boeing Aerospace Company
P.O. Box 3999
Seattle, Washington 98124

10. Work Unit No. (TRAIS)

11. Contract or Grant No.
DTUM 60-80-C-71009

12. Sponsoring Agency Name and Address
U.S. Department of Transportation
Urban Mass Transportation Administration
400 Seventh Street, S.W.
Washington, D. C. 20590

13. Type of Report and Period Covered
Development Report
Aug 1984 - Oct 1986

14. Sponsoring Agency Code
URT - 12

15. Supplementary Notes

16. Abstract

This report describes the development and test of a unique new Integrated Magnetic Propulsion and Suspension motor. This machine, designated as a Linear Synchronous Unipolar Motor (LSUM), utilizes rare earth permanent magnets to supply its magnetic field, giving primary suspension for a transit vehicle without significant energy consumption. The properties of the synchronous motor allow better utilization of the vehicle power conditioning equipment by obtaining a higher power factor and efficiency product than possible with the linear induction motor.

The LSUM was tested and evaluated in a static test facility. A complete documentation of lift and thrust performance over the full range of a vehicle operating scenario, and a description of magnetic flux in and around the machine were obtained.

The concept of supplying the unipolar magnetic field with rare earth magnets, and boosting that field with D.C. coils for lift control was proven during the test. The motor showed its potential for use in an automated public transportation system, particularly those systems that are characterized by a relatively low ratio of thrust to lift.

17. Key Words
Magnetic Suspension, Linear Synchronous Unipolar Motor, Automated Public Transportation, Magnetic Flux, Lift and Thrust Reactions.

18. Distribution Statement
Available to the public through the National Technical Information Service Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA-WA-06-0019-86-2	PB 88-166855	

4. Title and Subtitle Integrated Magnetic Propulsion and Suspension (IMPS) Final Report	5. Report Date December 1986
	6. Performing Organization Code
7. Author(s) R.G. Gilliland, D.D. Lyttle, G.W. Pearson	8. Performing Organization Report No.
9. Performing Organization Name and Address Automated Transportation Systems Boeing Aerospace Company P.O. Box 3999 Seattle, Washington 98124	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DTUM60-80-C-71009
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S.W. Washington, D. C. 20590	13. Type of Report and Period Covered Final Report 1979 - 1986
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report describes the development of critical technology for an Integrated Magnetic Propulsion and Suspension (IMPS) system for automated guideway transportation. Baseline work begun by Rohr Industries, in 1970, was picked up by Boeing Aerospace, beginning in 1978 and continued to the present. Significant gains were demonstrated in the areas of linear motor development, power control and conditioning, and in non-contacting air gap sensor and control system development.

The IMPS technology is seen to be competitive with magnetically levitated machines being developed in Europe and Japan. With continued development, the Linear Synchronous Unipolar Motor (LSUM) can make the IMPS technology competitive with steel wheel and rail transit on an energy consumption basis. It can provide a higher level of service and lower overall operating and maintenance costs than competing systems.

The IMPS technology and the development of solid state electronics have matured to where it is completely feasible to develop a full scale demonstration IMPS system.

17. Key Words	18. Distribution Statement
Gap Sensor, Controls, Automated Guideway Transportation, Integrated Magnetic Propulsion and Suspension, Linear Induction Motor, Linear Synchronous Unipolar Motor, Magnetic Levitation, Power Conditioning Unit.	Available to the public through the National Technical Information Service Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

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1. Report No. ERC-P-75075a	2. Government Accession No. PB 265966 PB 265967	3. Recipient's Catalog No.

4. Title and Subtitle
Guideway - Vehicle Cost Reduction
Part I: Guideway - Vehicle Performance and Costs
Part II: Active Suspension Feasibility

5. Report Date
July 9, 1976

6. Performing Organization Code

7. Author(s) D.L. Klinger, N.K. Cooperrider, J.K. Hedrick, R.C. White, A. Calzado, M.Sayers and D. Wormley.

8. Performing Organization Report No.

9. Performing Organization Name and Address
Arizona State University
Department of Mechanical Engineering
Tempe, Arizona 85281

10. Work Unit No. (TRAIS)

11. Contract or Grant No.
DOT-OS-50107

12. Sponsoring Agency Name and Address
U. S. Department of Transportation
Washington, D.C.

13. Type of Report and Period Covered
First Year
Final Report

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The cost and performance benefits of using improved suspensions in passenger railcars and urban buses are investigated. Preliminary results from the first year of a two year study are presented. The primary objective is to determine if improved vehicle suspensions can reduce overall system cost by allowing lower guideway maintenance standards. Cost determinations are limited to guideway annual maintenance and vehicle suspension installation and maintenance.

The guideway/suspension system is divided into several areas which are analysed separately. In Part I, transfer function models of passenger railcar and bus dynamics, and power spectral density models of guideway disturbances are developed. Preliminary guideway and suspension cost data are also analysed. In Part II, an assessment of active suspension feasibility is made which includes the preliminary design of a new low power pneumatic concept. A preliminary suspension/guideway maintenance cost tradeoff is described which shows that active suspensions are cost effective for low vehicle density routes.

17. Key Words
ride quality, transportation costs, guideway model, bus, railcar, active suspension

18. Distribution Statement
Document is available to the public through the National Technical Information Service, Springfield, VA 22151

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

CONTRACT PRICING PROPOSAL COVER SHEET

1. SOLICITATION/CONTRACT/MODIFICATION NO.

FORM APPROVED OMB NO. 3090-0116

NOTE: This form is used in contract actions if submission of cost or pricing data is required. *(See FAR 15.804-6(b))*

2. NAME AND ADDRESS OF OFFEROR *(Include ZIP Code)*

3A. NAME AND TITLE OF OFFEROR'S POINT OF CONTACT

3B. TELEPHONE NO.

4. TYPE OF CONTRACT ACTION *(Check)*

☐ A. NEW CONTRACT
☐ B. CHANGE ORDER
☐ C. PRICE REVISION/ REDETERMINATION
☐ D. LETTER CONTRACT
☐ E. UNPRICED ORDER
☐ F. OTHER *(Specify)*

5. TYPE OF CONTRACT *(Check)*

☐ FFP ☐ CPFF ☐ CPIF ☐ CPAF
☐ FPI ☐ OTHER *(Specify)*

6. PROPOSED COST *(A+B=C)*

A. COST	B. PROFIT/FEE	C. TOTAL
$	$	$

7. PLACE(S) AND PERIOD(S) OF PERFORMANCE

8. List and reference the identification, quantity and total price proposed for each contract line item. A line item cost breakdown supporting this recap is required unless otherwise specified by the Contracting Officer. *(Continue on reverse, and then on plain paper, if necessary. Use same headings.)*

A. LINE ITEM NO.	B. IDENTIFICATION	C. QUANTITY	D. TOTAL PRICE	E. REF.

9. PROVIDE NAME, ADDRESS, AND TELEPHONE NUMBER FOR THE FOLLOWING *(If available)*

A. CONTRACT ADMINISTRATION OFFICE

B. AUDIT OFFICE

10. WILL YOU REQUIRE THE USE OF ANY GOVERNMENT PROPERTY IN THE PERFORMANCE OF THIS WORK? *(If "Yes," identify)*

☐ YES ☐ NO

11A. DO YOU REQUIRE GOVERNMENT CONTRACT FINANCING TO PERFORM THIS PROPOSED CONTRACT? *(If "Yes," complete Item 11B)*

☐ YES ☐ NO

11B. TYPE OF FINANCING *(✓ one)*

☐ ADVANCE PAYMENTS ☐ PROGRESS PAYMENTS
☐ GUARANTEED LOANS

12. HAVE YOU BEEN AWARDED ANY CONTRACTS OR SUBCONTRACTS FOR THE SAME OR SIMILAR ITEMS WITHIN THE PAST 3 YEARS? *(If "Yes," identify item(s), customer(s) and contract number(s))*

☐ YES ☐ NO

13. IS THIS PROPOSAL CONSISTENT WITH YOUR ESTABLISHED ESTIMATING AND ACCOUNTING PRACTICES AND PROCEDURES AND FAR PART 31 COST PRINCIPLES? *(If "No," explain)*

☐ YES ☐ NO

14. COST ACCOUNTING STANDARDS BOARD (CASB) DATA *(Public Law 91-379 as amended and FAR PART 30)*

A. WILL THIS CONTRACT ACTION BE SUBJECT TO CASB REGULATIONS? *(If "No," explain in proposal)*

☐ YES ☐ NO

B. HAVE YOU SUBMITTED A CASB DISCLOSURE STATEMENT (CASB DS-1 or 2)? *(If "Yes," specify in proposal the office to which submitted and if determined to be adequate)*

☐ YES ☐ NO

C. HAVE YOU BEEN NOTIFIED THAT YOU ARE OR MAY BE IN NONCOMPLIANCE WITH YOUR DISCLOSURE STATEMENT OR COST ACCOUNTING STANDARDS? *(If "Yes," explain in proposal)*

☐ YES ☐ NO

D. IS ANY ASPECT OF THIS PROPOSAL INCONSISTENT WITH YOUR DISCLOSED PRACTICES OR APPLICABLE COST ACCOUNTING STANDARDS? *(If "Yes," explain in proposal)*

☐ YES ☐ NO

This proposal is submitted in response to the RFP contract, modification, etc. in Item 1 and reflects our best estimates and/or actual costs as of this date.

15. NAME AND TITLE *(Type)*

16. NAME OF FIRM

17. SIGNATURE

18. DATE OF SUBMISSION

When more than one contract line item is proposed, summary total amounts covering all line items must be furnished for each cost element. If agreement has been reached with Government representatives on use of forward pricing rates/factors, identify the agreement, include a copy, and describe its nature. Depending on offeror's system, breakdowns shall be provided for the following basic elements of cost, as applicable:

Materials—Provide a consolidated priced summary of individual material quantities included in the various tasks, orders, or contract line items being proposed and the basis for pricing (vendor quotes, invoice prices, etc.). Include raw materials, parts, components, assemblies, and services to be produced or performed by others. For all items proposed, identify the item and show the source, quantity, and price.

Competitive Methods—For those acquisitions (e.g., subcontracts, purchase orders, material orders, etc.) over $100,000 priced on a competitive basis, also provide data showing degree of competition, and the basis for establishing the source and reasonableness of price. For interorganizational transfers priced at other than cost of the comparable competitive commercial work of the division, subsidiary, or affiliate of the contractor, explain the pricing method (see 31.205-26(e)).

Established Catalog or Market Prices/Prices Set by Law or Regulation—When an exemption from the requirement to submit cost or pricing data is claimed, whether the item was produced by others or by the offeror, provide justification for the exemption as required by 15.804-3(e).

Noncompetitive Methods—For those acquisitions (e.g., subcontracts, purchase orders, material orders, etc.) over $100,000 priced on a noncompetitive basis, also provide data showing the basis for establishing source and reasonableness of price. For standard commercial items fabricated by the offeror that are generally stocked in inventory, provide a separate cost breakdown if priced based on cost. For interorganizational transfers priced at cost, provide a separate breakdown of cost by elements. As required by 15.806-2(a), provide a copy of cost or pricing data submitted by the prospective source in support of each subcontract, or purchase order that is either: (i) $1,000,000 or more, or (ii) both more than $100,000 and more than 10 percent of the prime contractor's proposed price. The contracting officer may require submission of cost or pricing data in support of proposals in lower amounts. Submit the results of the analysis of the prospective source's proposal as required by 15.806. When the submission of a prospective source's cost or pricing data is required as described above, it shall be included as part of the offeror's initial pricing proposal.

Direct Labor—Provide a time-phased (e.g., monthly, quarterly, etc.) breakdown of labor hours, rates, and cost by appropriate category, and furnish bases for estimates.

Indirect Costs—Indicate how offeror has computed and applied offeror's indirect costs, including cost breakdowns, and showing trends and budgetary data, to provide a basis for evaluating the reasonableness of proposed rates. Indicate the rates used and provide an appropriate explanation.

Other Costs—List all other costs not otherwise included in the categories described above (e.g., special tooling, travel, computer and consultant services, preservation, packaging and packing, spoilage and rework, and Federal excise tax on finished articles) and provide bases for pricing.

Royalties—If more than $250, provide the following information on a separate page for each separate royalty or license fee: name and address of licensor; date of license agreement; patent numbers, patent application serial numbers, or other basis on which the royalty is payable; brief description (including any part or model numbers of each contract item or component on which the royalty is payable); percentage or dollar rate of royalty per unit; unit price of contract item; number of units; and total dollar amount of royalties. In addition, if specifically requested by the contracting officer, provide a copy of the current license agreement and identification of applicable claims of specific patents. (See FAR 27.204 and 31.205-37).

Facilities Capital Cost of Money—When the offeror elects to claim facilities capital cost of money as an allowable cost, the offeror must submit Form CASB-CMF and show the calculation of the proposed amount (see FAR 31.205-10).

2. As part of the specific information required, the offeror must submit with offeror's proposal, and clearly identify as such, cost or pricing data (that is, data that are verifiable and factual and otherwise as defined at FAR 15.801). In addition, submit with offeror's proposal any information reasonably required to explain offeror's estimating process, including—

a. The judgmental factors applied and the mathematical or other methods used in the estimate, including those used in projecting from known data; and

b. The nature and amount of any contingencies included in the proposed price.

3. There is a clear distinction between submitting cost or pricing data and merely making available books, records, and other documents without identification. The requirement for submission of cost or pricing data is met when all accurate cost or pricing data reasonably available to the offeror have been submitted, either actually or by specific identification, to the contracting officer or an authorized representative. As later information comes into the offeror's possession, it should be promptly submitted to the contracting officer. The requirement for submission of cost or pricing data continues up to the time of final agreement on price.

4. In submitting offeror's proposal, offeror must include an index, appropriately referenced, of all the cost or pricing data and information accompanying or identified in the proposal. In addition, any future additions and/or revisions, up to the date of agreement on price, must be annotated on a supplemental index.

5. By submitting offeror's proposal, the offeror, if selected for negotiation, grants the contracting officer or an authorized representative the right to examine, at any time before award, those books, records, documents, and other types of factual information, regardless of form or whether such supporting information is specifically referenced or included in the proposal as the basis for pricing, that will permit an adequate evaluation of the proposed price.

6. As soon as practicable after final agreement on price, but before the award resulting from the proposal, the offeror shall, under the conditions stated in FAR 15.804-4, submit a Certificate of Current Cost or Pricing Data.

7. HEADINGS FOR SUBMISSION OF LINE-ITEM SUMMARIES:

A. New Contracts (including Letter contracts).

COST ELEMENTS	PROPOSED CONTRACT ESTIMATE—TOTAL COST	PROPOSED CONTRACT ESTIMATE—UNIT COST	REFERENCE
(1)	(2)	(3)	(4)

Under Column (1)—Enter appropriate cost elements.

Under Column (2)—Enter those necessary and reasonable costs that in offeror's judgment will properly be incurred in efficient contract performance. When any of the costs in this column have already been incurred (e.g., under a letter contract or unpriced order), describe them on an attached supporting schedule. When preproduction or startup costs are significant, or when specifically requested to do so by the contracting officer, provide a full identification and explanation of them.

Under Column (3)—Optional, unless required by the contracting officer.

Under Column (4)—Identify the attachment in which the information supporting the specific cost element may be found. Attach separate pages as necessary.

B. Change Orders (modifications).

COST ELEMENTS	ESTIMATED COST OF ALL WORK DELETED	COST OF DELETED WORK ALREADY PERFORMED	NET COST TO BE DELETED	COST OF WORK ADDED	NET COST OF CHANGE	REFERENCE
(1)	(2)	(3)	(4)	(5)	(6)	(7)

Under Column (1)—Enter appropriate cost elements

Under Column (2—Include (i) current estimates of what the cost would have been to complete deleted work not yet performed, and (ii) the cost of deleted work already performed.

Under Column (3)—Include the incurred cost of deleted work already performed, actually computed if possible, or estimated in the contractor's accounting records. Attach a detailed inventory of work, materials, parts, components, and hardware already purchased, manufactured, or performed and deleted by the change, indicating the cost and proposed disposition of each line item. Also, if offeror desires to retain these items or any portion of them, indicate the amount offered for them.

Under Column (4)—Enter the net cost to be deleted which is the estimated cost of all deleted work less the cost of deleted work already performed. Column (2) less Column (3) = Column (4).

Under Column (5)—Enter the offeror's estimate for cost of work added by the change. When nonrecurring costs are significant, or when specifically requested to do so by the contracting officer, provide a full identification and explanation of them.

Under Column (6)—Enter the net cost of change which is the cost of work added, less the net cost to be deleted. When this result is negative, place the amount in parentheses. Column (4) less Column (5) = Column (6).

Under Column (7)—Identify the attachment in which the information supporting the specific cost element may be found. Attach separate pages as necessary.

C. Price Revision/Redetermination.

CUTOFF DATE	NUMBER OF UNITS COMPLETED	NUMBER OF UNITS TO BE COMPLETED	CONTRACT AMOUNT	REDETERMINATION PROPOSAL AMOUNT	DIFFERENCE
(1)	(2)	(3)	(4)	(5)	(6)

COST ELEMENTS	INCURRED COST—PREPRODUCTION	INCURRED COST—COMPLETED UNITS	INCURRED COST—WORK IN PROCESS	TOTAL INCURRED COST	ESTIMATED COST TO COMPLETE	ESTIMATED TOTAL COST	REFERENCE
(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)

Under Column (1)—Enter the cut off date required by the contract, if applicable.

Under Column (2)—Enter the number of units completed during the period for which experienced costs of production are being submitted.

Under Column (3)—Enter the number of units remaining to be completed under the contract.

Under Column (4)—Enter the cumulative contract amount.

Under Column (5)—Enter the offeror's redetermination proposal amount.

Under Column (6)—Enter the difference between the contract amount and the redetermination proposal amount. When this result is negative, place the amount in parentheses. Column (4) less Column (5) = Column (6).

Under Column (7)—Enter appropriate cost elements. When residual inventory exists, the final costs established under fixed-price-incentive and fixed price-redeterminable arrangements should be net of the fair market value of such inventory. In support of subcontract costs, submit a listing of all subcontracts subject to repricing action, annotated as to their status.

Under Column (8)—Enter all costs incurred under the contract before starting production and other nonrecurring costs (usually referred to as startup costs) from offeror's books and records as of the cutoff date. These include such costs as preproduction engineering, special plant rearrangement, training program, and any *identifiable nonrecurring* costs such as *initial rework, spoilage, pilot runs*, etc. In the event the amounts are not segregated in or otherwise available from offeror's records, enter in this column offeror's best estimates. Explain the basis for each estimate and how the costs are charged on offeror's accounting records (e.g., included in production costs as direct engineering labor, charged to manufacturing overhead, etc.). Also show how the costs would be allocated to the units at their various stages of contract completion.

Under Columns (9) and (10)—Enter in Column (9) the production costs from offeror's books and records (exclusive of preproduction costs reported in Column (8)) of the units completed as of the cutoff date. Enter in Column (10) the costs of work in process as determined from offeror's records or inventories at the cutoff date. When the amounts for work in process are not available in contractor's records but reliable estimates for them can be made, enter the estimated amounts in Column (10) and enter in Column (9) the differences between the total incurred costs (exclusive of preproduction costs) as of the cutoff date and these estimates. Explain the basis for the estimates, including identification of any provision for experienced or anticipated allowances, such as shrinkage, rework, design changes, etc. Furnish experienced unit or lot costs (or labor hours) from inception of contract to the cutoff date, improvement curves, and any other available production cost history pertaining to the item(s) to which offeror's proposal relates.

Under Column (11)—Enter total incurred costs (Total of Columns (8), (9), and (10)).

Under Column (12)—Enter those necessary and reasonable costs that in contractor's judgment will properly be incurred in completing the remaining work to be performed under the contract with respect to the item(s) to which contractor's proposal relates.

Under Column (13)—Enter total estimated cost (Total of Columns (11) and (12)).

Under Column (14)—Identify the attachment in which the information supporting the specific cost element may be found. Attach separate pages as necessary.