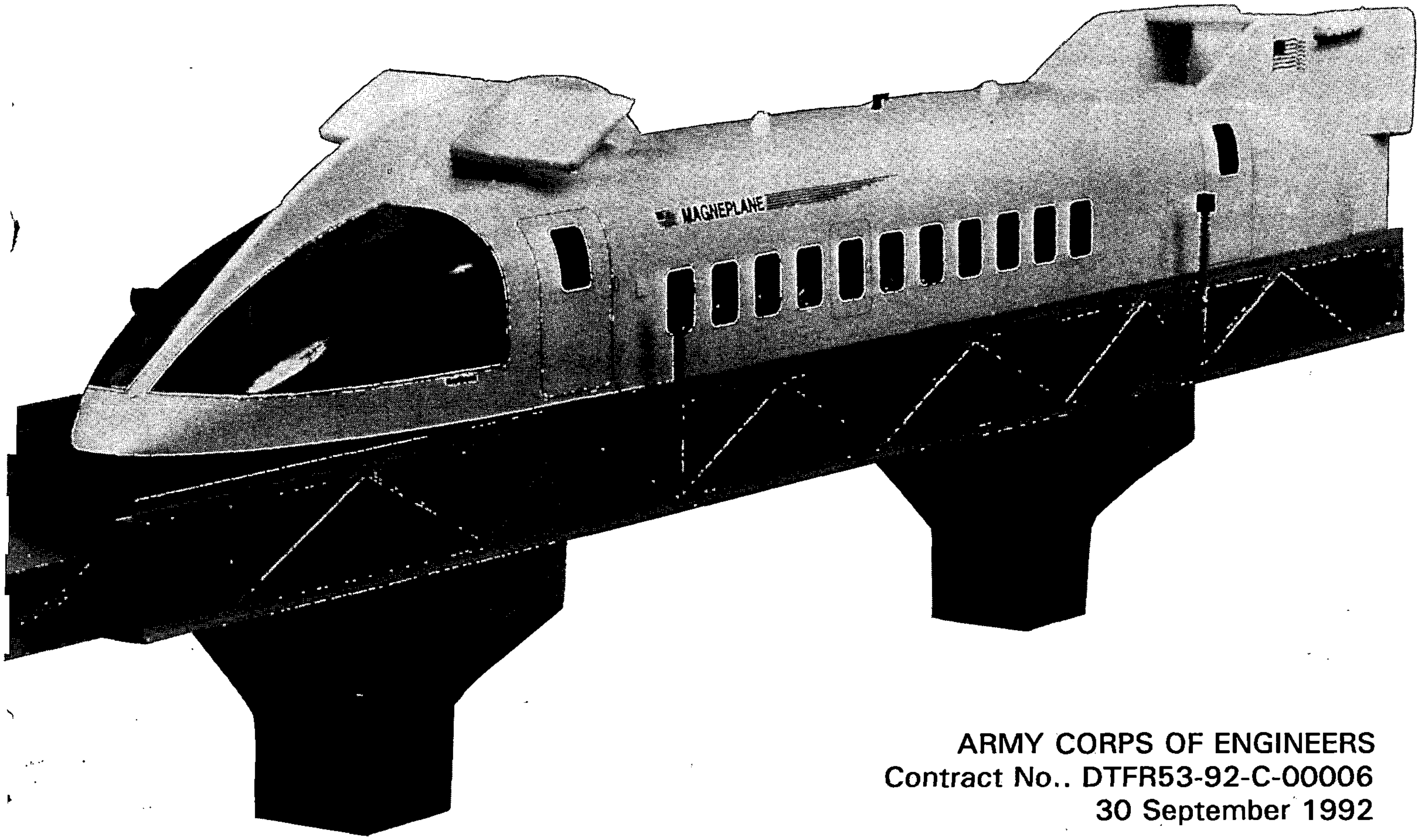
11 - Advanced Systems

Magneplane International • Massachusetts Institute of Technology
United Engineers and Constructors • Raytheon Equipment Division
Failure Analysis Associates • Bromwell & Carrier
Beech Aircraft Corporation • Process Systems International

SYSTEM CONCEPT DEFINITION REPORT
for the
NATIONAL MAGLEV INITIATIVE

Volume 5

5.3.8. PRELIMINARY ENVIRONMENTAL REPORT
5.3.9. TEST PLAN
5.3.10. SAFETY PLAN
5.3.11. LIFE CYCLE COST REPORT
5.3.12. COST ESTIMATE FOR SYSTEM DEVELOPMENT
5.3.13. EXTERNAL BENEFITS
INDEX



ARMY CORPS OF ENGINEERS
Contract No.. DTFR53-92-C-00006
30 September 1992

Magneplane International, Inc.
Jet Aviation Terminal, Hanscom Field West
Bedford, Massachusetts 01730
phone: 617 274 8750; fax: 617 274 8747

INDEX TO VOLUMES

LIMITED RIGHTS NOTICE

5.3.8. PRELIMINARY ENVIRONMENTAL REPORT

CONTENTS

5.3.8.1. TECHNOLOGY INTEGRATION

Not only is Magneplane International committed to meeting the transportation needs of the next century while revitalizing the economy, we are also committed to improvement of the environments. This report is an initial approach to the challenge of integrating a revolutionary technology into today's complex world.

5.3.8.1.a. THE ENVIRONMENTS

What are "the environments?" In this report, it is assumed that the environment comprises the geological, biological and cultural environments into which the technology will be integrated. Each of these environments will change with the development of maglev. This report is primarily concerned with the biological environment.

5.3.8.1.b. ENVIRONMENTAL ASSETS AND LIABILITIES

Any new mode of transportation will have extensive, fundamental, and long-lasting environmental impacts. Some of the environmental changes are assets and some are liabilities. Few of these changes can ever be reversed. For example, perfection of the boat ushered in an era of world-wide trade, but introduced a new brand of warfare. Development of the automobile opened the doors to convenient personal on-demand transportation, but it created dependence on foreign oil due to a high energy cost and became the world's major source of pollution.

Development of maglev will ultimately produce environmental assets and liabilities too. The proper integration of this radically new technology into the environments in question is a responsibility that is shared by Magneplane and its licensees, federal and local governments, and consumers. As is explained below, the Magneplane approach to maglev technology is environmentally sound and at the same time economically sensible.

Maglev is unusual because it was developed for non-military purposes, and has no use that is particular to the military.

5.3.8.1.c. TECHNOLOGY INTEGRATION METHODOLOGY

There are several potential ways to integrate maglev technology into the environments, and each method will have associated benefits and liabilities. The best way to achieve integration is by providing means to support the existing transportation system with the new system. In this manner, new infrastructure and development is minimized, along with the associated environmental impacts.

For example, Magneplane could accomplish this by selecting a magway corridor which is a section of interstate highway at maximum capacity. After construction, Magplanes will then be seen as the beneficial way to travel in terms of speed, cost, and energy efficiency, and will reduce automobile traffic along the corridor. This would have an additional improvement in overall energy use.

Once the corridor has been selected, Magneplane will utilize the existing right-of-way instead of requiring a new corridor. Traffic flow will remain separate for safety reasons, but magports will be located at existing people centers to reduce the need for additional infrastructure to the urban setting. Where new magports will be required, proper planning with local government or other concerns can minimize the potential environmental liabilities. Magports connect the maglev system to other modes of transportation, thus providing the last requirement of integrating the new technology with the old.

5.3.8.2. COMPLIANCE WITH ISTEA

The Magneplane transportation system is in keeping with the Intermodal Surface Transportation Act (ISTEA) of 1991, developed by the U.S. Department of Transportation, Federal Highway Administration. It combines the objectives of the Act with innovative design and construction techniques to minimize permanent and transient environmental impacts often associated with the development and operation of linear facilities. Primarily using existing right-of-ways, Magneplane will capitalize on established access routes, existing wildlife corridors and surface water drainage divides. Knowledge of sensitive or endangered species and their habitats will be expanded to address avoidance, as required by the federal and state permitting agencies, verses construction alternatives. Magneplane transportation system complies with the ISTEA goals in nearly all categories: flexibility, planning, environmental, aesthetics and research.

- **Program Flexibility**

  ISTEA gives the flexibility for state and local governments to choose conventional or alternative transportation systems for qualifying federal funds. Therefore local officials are able to identify and evaluate alternatives which best suit their needs. Magneplane offers high speed travel but it also offsets several environmental impacts currently associated with conventional ground travel. When evaluating transportation alternatives, factors related to air quality, congestion, environmental impact and mitigation will be part of the critical path analysis. ISTEA embraces new technologies to be part of this analysis, seeking long term solutions over the short term.

- **Planning**

  ISTEA initiates a requirement for a statewide planning process. Although the impetus is through the amendments to the Clean Air Act, ISTEA recognizes that the future needs are to emphasize intermodal transportation. The strength in this consideration is the close coordination with land use planning, current and future development, economics, energy demands and environmental and social effects of an integrated transport system. Special funding has been set aside for air quality planning and congestion mitigation, supporting an air quality improvement program. Projects and programs which are specifically designed to address these problems now have a special funding source to ensure financial support.

A maglev transport system would reduce air quality impacts since it is operated by electricity. However, secondary impacts related to power production (nuclear, gas, oil or coal) would need to be evaluated. The high occupancy magplanes would relieve further stress on ground transportation systems, further improving air quality and reducing congestion. However, ground support will be needed to service the magports. Transport systems such as Magneplane have great flexibility and will be able to service multiple access points without interrupting other transportation systems and the primary magway. This will increase ground entry into the system from multiple entry points as needed in the larger metropolitan areas. This will further reduce existing ground congestion and discourage the development of new crowded locations.

- **Environment and Aesthetics**

Funding under the Surface Transportation Program (STP) and the National Highway System (NHS), both provisions under ISTEA, offers a mechanism to seek wetland mitigation banking in advance of impact. With the proposed construction methods associated with the elevated magway, environmental impact will be reduced as compared to a conventional ground system. However, it will be inevitable that wetland areas will be impacted by the magway. ISTEA offers a means for addressing the impacts up front, reducing the possibility of permitting delays prior to construction. ISTEA also encourages early acquisition of right-of-way. Prudent environmental planning will reduce future environmental impacts as well as preserve vital corridors from other development.

- **Environmental Research**

ISTEA increases the funding available for environmental research related to air quality, wetlands and other pertinent environmental issues. Magneplane transportation provides reduced impacts to air quality at the source since the magplanes are propelled by an electric motor instead of a combustion engine. However, a power source is required, therefore, secondary impacts related to the operation of the source power facility would need to be evaluated to provide a fair comparison of air quality impacts.

Wetland impacts would either be avoided or reduced through end-on construction methods. Also the magway should provide a 50 year life therefore reducing the maintenance below that required of a conventional rail or highway transportation route. Other positive environmental features of the maglev transport system is its ability to traverse sensitive habitats and unique land forms because of the elevated magway. Although pier placement would cause some disturbance, the overall impacts to the ecosystem would be minimal and temporary using the end-on construction techniques.

5.3.8.3. ENVIRONMENTAL ISSUES

Section 5.3.8.3. contains specific analyses regarding fourteen major environmental issues, problems, or areas of study. For each environmental topic, four questions are answered.

1. What is the isolated environmental impact of the Magneplane system?

2. What measures can be used to mitigate the environmental liabilities and enhance the environmental assets?

3. What is the environmental impact of alternative technologies?

4. What is the net environmental effect after Magneplane integration?

The purpose of asking and answering these four questions on each topic is to give the reader an understanding of the net effect of the integration of the Magneplane system, not just the isolated effect. We also wish to alert the reader to the possible alternatives to Magneplane integration, such as continued expansion of automobile use, and to point to some of the consequences of those alternatives.

5.3.8.3.1. R.O.W. IMPACT

The physical aspects of inserting a new transportation system into the urban environmental setting are varied. There will be impacts from both construction and from operation of the system. Route selection will take into consideration cost, logistics and environmental impacts and safety factors. The chosen routing will capitalize on existing corridors which includes highway, rail, pipelines and utilities. Inserting the maglev system into an urban setting will impact adjacent real estate.

Construction impacts are expected to be small compared to other conventional transportation systems and will be related to routing, system configuration and techniques used in construction.

The system consists of the following construction elements:

- magway
- power distribution line
- power substations and converter stations
- magports (in-line, off-line, or way-off-line), including
    - magport building
    - intermodal service area (parking, train connection, etc)
    - entry/exit ramps

Magports positioned strategically along the magway will be smaller than conventional rail or airplane passenger stations due to the dynamic scheduling capabilities of Magneplane. Therefore, although the nature of the magport impacts are similar, the Magneplane magport impact will be less extensive due to the smaller area required.

Magway elements will be above, below and at-grade. Elevated magway will consist of varying span lengths and span heights as may be dictated by the requirements of the terrain traversed. Spans are supported on piers set on footings which requires a small "foot print" and a minimal environmental impact. At-grade magway and tunnel portals to below grade magway create the greater environmental impact, i.e. the continuous "foot print" of the magway at-grade. Therefore, the elevated magway on piers is perceived as causing the least R-O-W environmental impact compared with at-grade and below grade magway configurations.

Repetitive components of the maglev system such as piers, magway spans, box beams, etc. can be fabricated under controlled conditions in the "shop" and moved for erection in the field. This technique will minimize R-O-W impacts because it reduces or eliminates many of the field fabrication activities responsible for environmental disruption, such as craft parking, laydown areas, construction wastes, etc.

Methods are being used in highway construction to cross sensitive areas (e.g., wetlands) in order to minimize environmental R-O-W impacts. This is a top down technique called end-on construction. This method is adaptable to maglev. With this method, the conventional haul road/access road, which is the primary source of disturbance in sensitive areas, is eliminated and the construction leap-frogs from pier to pier using the constructed path on the piers as the haul road.

Elements of the maglev system that will directly impact the R-O-W are the magway, tunneling requirements and magports. Impacts are compared qualitatively below with respect to their perceived severity.

	Perceived Impacts	
Considerations	**Least**	**Greatest**
Route selection	Highway corridor	New corridor
System elements	Elevated magway	At-grade magway
Construction methods	Shop fabrication	Field Fabrication
Construction methods	End-on	Conventional

Magneplane is well suited to routing along existing interstate highways. It is capable of steep banking at high speeds and is compatible with highway curves. Rail transportation corridors, although narrower than interstate highways, could be equally suitable provided corridor widths were adequate and did not require additional R-O-W acquisition. Utility R-O-W has certain limitations and constraints. Pipelines (i.e., crude oil, natural gas, etc.) traverse considerable distances but possibly are not suitable for safety reasons. Sewer and surface drainage easements could be unsuitable due to their location in flood plains that experience periodic flooding.

New, dedicated R-O-W for the maglev system is perceived to cause the greatest environmental impact to both undeveloped and developed urban areas. Although, the double magway is only 11 m (36 ft.) wide, the width of the R-O-W will need to be greater to accommodate enclosure fencing, access road, and certain setback requirements as a possible means to mitigate electromagnetic emissions and noise emissions.

As discussed above, ISTEA promotes an integrated planning process among local, state and federal officials to develop intermodal transportation networks. The corridor selection process will address area zoning, permitting, infrastructure, sensitive lands and economics.

This process is critical for evaluating the environmental impacts because it will influence corridor location, magway configuration, construction options, and mitigation criteria. The feasibility study will include:

- land use: current and future
  comprehensive planning
  interlocal agreements
  local ordinances
- land ownership: public vs. private
- vegetation mapping
- wildlife inventory and habitat assessment
- unique land forms & sensitive lands
- recreation and open space areas
- permitting criteria
- economic evaluation of avoidance verses mitigation

Operation of the system will be comparable to conventional transportation systems, with additional unique elements. As with conventional systems, the R-O-W will need to be maintained, the system maintained and serviced, and magports need to be provided to accommodate passengers and their parking needs. Uncommon impacts will include aesthetic values and emissions of noise and electromagnetic fields from the operating system.

Automobile traffic volume is expected to increase around magports. However, this traffic is being removed from highway routes and inserted into the maglev system reducing highway traffic volume along the distance between the magport and the destination point. Access to the maglev system will best be accommodated with magports and parking being accessed from interstate or other high volume highways, if not directly off an access road, then near with connections to other modes of transportation (bus, subway, taxi).

Maintenance and servicing of the R-O-W and system are not expected to impose additional impacts over and above those that already exist from installation of the system.

5.3.8.3.2. NOISE

The present modeling of the noise impact of operating a 145 passenger magneplane vehicle predicts an excess of the noise emission regulations for trains as defined in FRA 49 CFR Ch. II Part 210 and EPA 40 CFR Ch. I, Part 201. Therefore mitigative measures and/or design refinements will be pursued to abate the noise impact as much as practical. (Graphical representations of computer modeling results are found in Section 3.2.2.f.1, Vehicle Aerodynamic Properties.)

In review of the variables which impact the noise element of designing and operating a magneplane vehicle the following noise mitigation techniques may be employed:

Aerodynamic noise control
- clean aerodynamic shape
- boundary layer transition control
- flow separation control using aerodynamic surfaces

Sound propagation control by magway barriers
- re-direction of the sound
- absorption through internal reflections

Vehicle operational procedures
- speed reduction in noise-sensitive areas
- increased width of rights-of-way to provide noise dissipation with distance
- effective use of natural sound barriers such as topography and vegetation

In contrast to the existing transportation options (automobile, truck, train and airplane) the operation of magneplanes will reduced the combined noise impact of alternative transit. Therefore the combined net effect will be attractive to sensory perception.

The noise disturbance due to a single vehicle passing, as currently designed, would have a "startle" effect which, through sensitive areas such as neighborhoods, could be controlled by reducing speed. Magneplane noise, however, would be replacing the negative sensory impacts associated with vehicular traffic (horns, SO_2 emissions, burning oil, rubber debris, and engine noise); airplanes (engine roar); and trains (track noise, whistles, and obstruction to vehicular traffic).

Based on computer modelling, magneplane noise can be severe at very high speeds and will impact noise-sensitive areas along the R-O-W such as residential areas. Aerodynamic noise is the dominant source of noise and the single most important contribution at design speed is the turbulent boundary layer flow on the body of the magplane. Modelling has included parametric studies of the vehicle to magway interaction to reduce the noise levels.

5.3.8.3.3. VISUAL IMPACT - MOVING

The most significant visual impact of the moving transport vehicle will have to do with the "startle effect". But since the Magneplane is a high-speed transportation system this effect will be short, as opposed to the constant stream of highway traffic or long, slow moving railway cars. Any initial annoyance factor or visual distraction experienced by the observer or user is not expected to be a significant impact or lasting distraction.

Initial annoyance or startle effects will be overcome as observers and users become accustomed to the new system, especially if it is architecturally pleasing with an aesthetic magway design.

5.3.8.3.4. VISUAL IMPACT - BACKGROUND

The insertion of an additional element into the urban environment will result in new visual impacts. These impacts are associated with a departure from usual urban elements. That is, most urban development is expressed in the lines of vertical structure (buildings, etc.), and although the magway supports are compatible with this pattern and will not "obstruct the urban scenic vistas", the horizontal magway will constitute a new and perhaps disruptive or distracting element. However, this should not be a significant impact or a lasting distraction.

Elevated magway and the supporting piers will add new elements to the existing urban visual setting. The elevated magway will have a similar visual impact to overpasses, interchange flyovers, etc. of interstate highways. The pier impact will be similar to the supports for these interstate highway elements. The visual observer perceives vertical forms as the predominant theme in an urban setting (apartment building, office building, highrises, etc.). So, the maglev system elements of the magway are not foreign to the existing urban environment, just new.

Significant visual impacts or distractions are not expected to accompany the operation of the system. At-grade magway is perceived as less of a distraction than either a rail system (with ballast and cross ties) or an interstate highway (wide R-O-W with multiple vehicle lanes, median strip and controlled access roads and ramps). Most if not all the metal trough with the LSM winding will be hidden from view in the magway at-grade. Portals leading to below grade magway in tunnels will be similar to portals for other modes of transportation. At-grade guide and tunnel portals an be made more aesthetically pleasing by the strategic use of landscaping. Vegetation plantings may be expeditiously used to break up the continuous line created by at-grade magway.

Any initial visual distractions or annoyance factors will be overcome as observers and users become accustomed to the new system especially if it is architecturally pleasing with an aesthetic magway design. The system elements new to the visual setting should be comparable with respect to textures, colors and hues of the immediate surroundings. The expeditious use of landscaping will further enhance the aesthetics of the system.

5.3.8.3.5. EMI/EMC

There are several sources for electromagnetic interference caused by the propulsion system of the Magneplane concept.

The power converters of the Magneplane system use a diode rectifier circuit which develops non-sinusoidal input currents. These non-sinusoidal currents are described in terms of their harmonic content. The first harmonic is 60 Hz, the second harmonic is 120 Hz, and so on. Typical harmonic currents allowed by utility companies are:

- No single harmonic current should be more than 3% of the 60 Hz line current.
- The total harmonic current should not be more than 5% of the 60 Hz line current.

Converters on the Magneplane system will typically have an input circuit consisting of two, three-phase rectifiers connected in a 12-pulse configuration. Two groups of 12-pulse rectifiers can also be used to construct a 24-pulse rectifier. Current harmonics from 12 and 24-pulse rectifiers occur at odd frequencies which are related to multiples of the pulse number. 12 pulse rectifiers generally having higher harmonic currents than 24 pulse rectifiers. In some cases 12 pulse rectifiers will require harmonic filters on the ac line side to reduce the harmonics. 24 pulse rectifiers can usually meet the utility guidelines without harmonic filters. Typical harmonics are given in IEEE 519, IEEE Guide for Harmonic Control and Reactive Power Compensation.

There are three options for meeting typical utility guidelines for ac side current harmonics:

- Use 12 pulse rectifiers and harmonic filters
- Specify 24 pulse rectifiers on all the converters.
- Stagger the phasing of individual converters in each converter station to create the effect of 24 pulse (or higher) operation.

The best solution depends on the specifics of the power system, converter sizing and other factors. In general the cost impact will not be significant.

The power converter equipment now being considered by Magneplane is commercially available and is in use in many industrial applications. The applications include factories, power generating stations, and pumping stations for water processing. It is our understanding that the equipment meets all the applicable standards required for installation in these environments. Since the intended application on the Magneplane System is similar to these applications we do not expect any problems related to electromagnetic radiation from the equipment.

The most important factor which reduces the potential for electromagnetic interference from the Magneplane magway is the design of the LSM winding. The winding geometry is such that the three phases are much more highly coupled than those of an ordinary transmission line. In fact the winding design has been optimized to radiate efficiently only in a horizontal plane 0.25 m above the winding. Magnetic field analysis shows that the field is very small at distances beyond several meters in any direction.

Nonetheless the radiation pattern and the magnitude of currents must be considered when assessing the potential to cause interference. There are two sources of high currents in the LSM winding:

- Propulsion current: up to 3000 A , up to 100 Hz
- Auxiliary power current: 400 A at 500 Hz

IEEE 519 guidelines for telephone interference effect have been reviewed with respect to these sources. Interference at the propulsion frequency is not a serious concern because of the low frequency. Harmonics in the propulsion system are probably not a problem since the currents are reduced by the tuned circuit effect of the LSM power circuit. The auxiliary power frequency appears to be a problem based solely on the IEEE guidelines. Unfortunately the guidelines are based on the geometry of transmission lines which develop long radiating waves parallel to the direction of the lines. A more thorough investigation of the guidelines may be needed when a detailed design is conducted. But interference should not be a problem because of the radiating pattern of the LSM winding.

The feeder cables from the power converter to the LSM winding will be configured in a tightly coupled arrangement and carried in metallic cable trays adjacent to the magway. As a result, their radiation will be significantly less than the LSM winding itself. It is not expected that radiation from these cables will be a source of significant electromagnetic interference.

5.3.8.3.6. MAGNETIC FIELDS

Magnetic fields surround many things, for example, electrically powered tools and appliances, electric power transmission lines, household interior wiring, etc. Magnetic fields are also produced by maglev, by both the vehicle magnets and the LSM windings in the magway. The field strengths of magnetic fields are measured in Gauss (G) units and are described below. The field strength of the maglev magnetic field is compared to fields associated with the earth's magnetic field and to those for electric power lines.

The magway magnetic fields close to the vehicle are steady state dc magnetic fields. The vehicle floor level is about 1 m above the magway winding. The flux density at this distance is below 1 G. Although there are no existing standards for continuous exposure to steady state dc magnetic fields, the earth's field of about 0.5 G may be used for comparison.

The magway magnetic field computed over a range of 10 m from the magway is shown in section 5.3.6. The field at 10 m below the magway is below 5 mG. The field falls below 0 mG at 3 m distance to the side. For comparison, a continuous ac exposure level of 200 mG at the edge of a transmission line right-of-way has been adopted by the state of New York. Even with elevated currents in the magway, up to 3000 A, the fields will be well within the 200 mG guidelines established for transmission lines.

The levitation modules and propulsion coils in the bogies near the ends of the vehicle produce magnetic fields and several schemes have been examined to shield the cabin of the vehicle. In the base case, active coils were judged appropriate to provide shielding to the 1 - 5 G level. See section 5.3.6.2. for a detailed discussion.

Magneplane will use a 34.5 kV distribution system to power magway blocks of up to 2 km in length. As may be required by a specific route, a 69 kV distribution may be needed. Typically, the distribution system would be connected to a major transmission line, say 500 kV.

The ac magnetic field strength for distribution and transmission systems are tabulated below in mG relative to distance from the source.

Distance	Distribution System	Transmission Line
1 m	1 - 20	40 - 500
10 m	0.2 - 12.5	40 - 450
100 m	< 0.01 - 0.7	0.8 - 10.5

The state of New York has adopted an exposure level for continuous ac exposure at the edge of a transmission line right-of-way of 200 mG. Florida, Massachusetts and New Jersey are planning to adopt similar requirements.

5.3.8.3.7. AIR QUALITY

One of the most significant environmental benefits to be gained from the use of the Magneplane system will be in the reduction of automobile exhaust emissions. Automobiles are the largest source of air pollution, and a major contribution to the "greenhouse effect". The high occupancy Magneplane vehicles will relieve stress on highway routes, reducing vehicular traffic, air pollution and congestion.

Operation of the Magneplane system is essentially a "clean" operation with no combustion by-products to contend with. Operated on electricity, the only air contaminants associated with the system would have to do with the power source; be it gas, oil, coal or nuclear.

Successful integration of the Magneplane system will help to spur the development of domestic fuels such as safe nuclear power, and reduce our dependence on polluting fossil fuels.

With the availability of alternative transportation systems, dependence on auto travel can be minimized and tighter air quality standards may be more economically and socially feasible. The alternative is to have continued increases or at best, the same levels of airborne pollution using the existing technologies of auto, plane and train.

5.3.8.3.8 WATER QUALITY

The elevated magway offers a preferred alternative in sensitive environmental areas over conventional road or rail construction. These are generally constructed on elevated pads or berms to ensure proper surface water drainage during weather events. These structures not only interrupt natural drainage patterns but often require additional fill to traverse wetland areas or unstable land forms. Construction of these impoundments further complicates permitting procedures by requiring additional filling impacts in wetland areas, and requires placement and maintenance of artificial drainage structures to ensure flow is maintained through the berm.

Water quality becomes affected by the alteration of the natural drainage patterns, through the construction of the fill pads and from typical road and/or rail run-off. Construction of conventional roads or rail foundations necessitate land clearing and berm construction. This alteration of natural vegetation and topography results in increased potential for erosion and associated sedimentation in nearby aquatic habitats. Elevated magways eliminate the need for linear fill structures which block natural drainage. The amount of clearing and construction of fill pads will be limited to those areas required for support structures, drastically reducing the impacted area.

If magway replaces traffic lanes, it eliminates the surface area required by road embankments on which petrochemicals, salts, lead, mercury, and other pollutants collect and ultimately wash into nearby water bodies and wetlands. Nationally, it is recognized that urban stormwater runoff, principally from roadways, is the major source of water pollution. Maglev transportation will eventually serve to improve water quality by reducing highway usage and the associated source of water pollution.

5.3.8.3.9. WETLANDS CONSERVATION

Sensitive wetland habitats and vegetation communities, preserved open space areas, threatened and endangered wildlife habitats, paleokarst features, unconsolidated subsurface materials, and the interruption of surface water flow patterns, can all be avoided by using the elevated magway. All of these factors cause permitting difficulties when constructing a conventional linear corridor for utility, auto or rail. In addition, the elevated magway lends itself to end-on construction techniques which allow for advance of the piers and spans to be constructed from the end magway span, above these sensitive areas. This construction method virtually eliminates land surface alterations with the exception of the pier placement.

Because of the light-weight vehicles, the pier foundations will be relatively small, as compared to conventional train and road bridge construction. These smaller footings will further minimize and localize the environmental impact of the construction area. Wetland fill impacts will be minimized, thereby reducing mitigation requirements and permitting difficulties.

If wetland impacts are unavoidable, the permittee will be required to compensate for this loss through mitigation. Mitigation criteria usually requires the creation, restoration, or enhancement of an in-kind system at a ratio greater than what was impacted. Preferred mitigation sites are typically located within the same drainage basin as the impact area.

ISTEA offers funding to create a mitigation bank which could serve to compensate for all or part of the wetlands impacted within certain spans of the magway. Mitigation alternatives would depend on regulatory agency negotiations and agreement on compensation ratios, enhancement, restoration, creation, preservation and/or mitigation banking options.

Following construction, maintenance requirements and therefore disturbance to wetlands and other sensitive habitats will be minimal. The magway is resilient and robust, and is designed for a fifty year life thereby reducing maintenance typically required of conventional rail and highway transportation routes.

5.3.8.3.10. WILDLIFE HABITAT

Critical habitats and the presence of threatened or endangered species within the corridor will be identified during preliminary planning, and avoided to the greatest extent possible. The elevated magway, however, provides unique features which will minimize impacts to wildlife and vegetative communities. The magway is supported by individual piers with span lengths of between 30 and 120 feet. Long spans will be utilized as appropriate in sensitive areas to allow for uninterrupted wildlife corridors both during construction and operation of the system. End-on construction techniques will eliminate disturbance of vegetation, soils and the presence of heavy equipment within critical habitat areas.

The Magneplane system will be constructed along existing transportation corridors, thereby eliminating the need to disturb previously undeveloped or pristine habitat areas. The lack of elevated fill pads and uninterrupted corridors created by conventional road and rail routes will also avoid further fragmentation of remaining habitats and wildlife corridors. High wildlife mortality is frequently associated with busy highways, and often affects populations of threatened and endangered species such as the Florida panther. The magway will pose no threat to crossing wildlife and with decreased highway usage may actually assist in reducing traffic related wildlife mortality.

Any temporary impacts to critical habitats or threatened or endangered species can be mitigated as appropriate. These minor impacts may be in the form of clearing of nest trees or foraging areas. Re-planting, habitat restoration and/or species relocation programs can be carried out as appropriate in such instances.

The only other perceived adverse impact to wildlife may involve the noise associated with the passing transport vehicle. It is anticipated that any affect would be minor and temporary as the passage of the Magneplane is fleeting and wildlife will quickly adjust to the brief presence and associated sound.

5.3.8.3.11. SOIL CONSERVATION

For the reasons discussed above, soil conservation will be best served by the proposed Magneplane system over conventional road and rail transportation technologies. Construction and operation of the elevated magway involves minimal alteration to land forms, wetlands and habitats. Pier foundations will be relatively small compared to those used in typical road and rail bridge construction. Need for fill pads and berms will be substantially reduced, natural drainage patterns left relatively unaltered, required clearing and filling will be kept to a minimum, and road run-off will be eliminated. This avoids the increased erosion problems associated with typical road construction and operation. The net environmental effect of this maglev system is to improve soil conservation.

5.3.8.3.12. LAND COVERAGE

The Magneplane system is designed for the most economical use of land space possible. The system is adaptable to existing corridors and can operate on the ground or as an elevated magway.

Magneplane is well suited to routing along existing interstate highways. It is capable of steep banking at high speeds and is compatible with highway curves. The width of a double magway is approximately 11 m (36 ft.) which requires much smaller R-O-W width than that needed for a four lane interstate with median strip and access roads. Rail transportation corridors, although narrower than interstate highways, could be equally suitable for use with maglev technology provided corridor widths are adequate.

Land coverage is also affected by the magports, which accommodate passengers and freight. Magports positioned strategically along the magway will be smaller than conventional rail passenger stations due to the dynamic scheduling capabilities of Magneplane. Although magport impacts are similar to other modes of mass transportation, the Magneplane magport impact will be less extensive due to the smaller area required.

Magway elements will be above, below and at-grade. Elevated magway will consist of varying span lengths and span heights as may be dictated by the requirements of the terrain traversed. Spans are supported on piers set on footings which makes for a small "foot print" requiring minimal environmental impact and land use. At-grade magway and tunnel portals to below grade magway create the greater environmental impact, i.e. the continuous "foot print" of the magway at-grade. Therefore, the elevated magway on piers is perceived a causing the least R-O-W environmental impact compared with at-grade and below grade magway configurations.

The Magneplane system will be constructed bi-directional, allowing for cross-overs and turnouts. The embarkation/debarkation magport locations can be located at existing people centers, such as malls, train stations, airports, industrial parks, amusements parks and the like, taking advantage of existing infrastructure.

Transportation using a Magneplane has great flexibility in that it is able to service multiple access points without interrupting traffic flow on the primary magway. This will increase ground entry into the system from multiple entry points as needed in the larger metropolitan areas. This will further reduce existing ground congestion and discourage the development of new crowded locations.

Construction techniques have also been identified which will make the greatest use of available space with minimal environmental impact. Repetitive components of the maglev system such as piers, magway spans, box beams, etc. can be fabricated under controlled conditions in the "shop" and moved for erection in the field. This technique will minimize R-O-W impacts because it reduces or eliminates many of the field fabrication activities responsible for environmental disruption such as craft parking, laydown areas, construction wastes, etc. often associated with typical road and bridge construction.

The net result will be a much more prudent use of available land compared to land required to build new and upgrade existing roads and highways. Use of the Magneplane system will help to eliminate the need for future road upgrades to accommodate typical increases in traffic congestion. Therefore the net environmental effect is to improve land use by providing a more efficient means of transportation.

5.3.8.3.13. SOLID WASTE

The low maintenance and long life features of the Magneplane system promote minimal solid waste generation. Waste typically associated with construction, operation and maintenance of roads and highways such as fuel waste, tar and asphalt and other construction debris will be eliminated or substantially reduced. Solid waste generated by fuel stations and other commuter and transportation support facilities will also be reduced.

Old automobiles and parts, particularly tires, currently represent a significant portion of the nation's solid waste problem. Use of the Magneplane transport system will eventually lead to a reduction in automobile usage thereby decreasing the demand for cars, tires and replacement parts. The problems associated with disposal of used motor oil will also be avoided.

An interesting aspect of solid waste reduction is the recyclability of the Magneplane system. Aluminum, the principal construction material of the magway, is one of the most widely recycled material in the U.S. In the future, old sections of magway will be removed, recycled, and put back to use within the system - thus reducing solid waste normally associated with maintenance of transportation systems. Similar recycling efforts are being demonstrated in the roadway industry, with recycling of pavements as a major development effort over the last 10 years. It is projected that this maglev technology will have little change on solid waste generation, or possibly a reduction.

5.3.8.3.14. SPACE CONSERVATION

As discussed in previous sections, the proposed Magneplane system provides the most conservative use of space compared to conventional transportation system alternatives. The system is designed to be constructed wherever possible on existing road, rail or utility corridors and can operate on the ground or as an elevated magway.

Magneplane allows steep banking (therefore high speeds) and curve radii compatible with highways. The maglev system has a small "footprint" when elevated magway is used and would result in minimal additional space requirements in an existing transportation corridor. The magway pilings are easily placed on footers in highway medians or on right-of-way adjacent to roadways. Placement of piers and footers would depend on single vs. double magway. The most efficient structure supporting a double magway consists of double columns (one column centered under each magway). It is possible, however, for a nominal increased cost to support a double magway on larger single columns. Nevertheless, impacts are perceived least disruptive environmentally when the maglev system is routed along existing automobile transportation corridors.

The width of a double magway is approximately 11 m (36 ft.) which requires a much smaller R-O-W than that needed for a four lane interstate with median strip and access roads.

Maglev magway construction along abandoned rail corridors would also be possible; active rail routes would be more difficult due to the probable need to acquire added right-of-way. Rail grades are not as steep generally as highways and curve radii are more generous. Although abandoned routes may not be very numerous and active rail routes possess some of the same problems as new corridors (i.e., acquiring added right-of-way), these corridors are least environmentally disruptive, second only to automobile highway routes. The small "footprint" of the piling/footer of the elevated magway lends itself well to the use of rail transportation corridors should these corridors have the desired connections to major transportation routes.

New routes on either public or private land would be possible only at high cost and considerable additional space requirements. Building new corridors in areas where maglev systems are most needed would also be the most environmentally disruptive and require increased land acquisitions. Undeveloped land would need to be cleared of vegetation and prepared for construction. Developed land may need to be cleared of existing structures and right-of-way would need to be acquired through purchase or condemnation. This would not only be a disruptive process but a costly one that might render the project not economically feasible if a dedicated maglev system transportation corridor were to be used.

Additional potential existing corridors are rights-of-way presently used for electric power transmission, hydrocarbon pipelines, large interceptor sanitary or storm sewers and surface drainage ditches. There are benefits and costs to each of these and while pipelines and transmission lines traverse great distances there are overriding safety considerations. Sewer and drainage ways have other problems. They usually do not cover long distances and often are located in flood plain areas subject to flooding. If these disadvantages could be overcome and if these corridors could be used for a short distance along part of the route, magways could be constructed with minimal additional impact to corridors that are already environmentally disturbed.

As discussed earlier, Magports will be smaller than conventional rail passenger stations thereby conserving additional space over new and existing rail routes. The impacts of magports and parking to accommodate the ridership is similar to conventional systems. However, the physical requirements for area needed will be less than conventional systems because Magneplanes dynamic scheduling capabilities allows for these smaller magports. Stacked parking for the ridership (i.e. parking garage) can also reduce the space needed compared to surface parking. Thus, the design of the Magneplane system which allows smaller magports and the conscious choice for parking design will decrease the space requirements that would otherwise be expected from conventional transportation systems.

Magports can be located in spaces already being used for multiple purposes in the urban setting, thus improving space conservation. By utilizing properties which have been run down, urban renewal and economic revival can be spurred with the development of a magport. Careful interaction with municipal planners will result in the best possible use of lands at magports.

Use of available space will also be maximized during construction to keep environmental impacts to a minimum. The spans of the magway, metal saddles, box beams, etc., the repetitive components of the system, lend themselves to shop fabrication. The prefabricated members can be transported to the field and erected with a minimum of environmental impact and at less cost when compared to field labor and field fabrication.

New techniques developed and used to construct a highway traversing sensitive areas such as wetlands, the riparian and littoral zones of rivers, lakes and estuaries are applicable to elevated magway crossing these areas (Section 3.2.2.e.2). The method is called end-on construction.

The conventional method would first build a temporary haul road, then build the permanent magway and finally remove and clean up the haul road (or leave it as a maintenance/emergency access road). End-on construction is a top-down scheme whereby the crossing itself (highway or magway) is the haul road and provides access as the structure is "leap-frogged" forward from one pier support to the next. The construction area is thus confined to the immediate vicinity of the pier and the environmental impact is significantly reduced, although construction costs are usually greater and a separate vehicular access road is not provided.

Space conservation can be maximized through effective planning in route selection and magport location. The net effect of this new technology on space conservation is to minimize impacts.

5.3.9. TEST PLAN

CONTENTS

FIGURES

5.3.9.1. TEST PLAN INTRODUCTION

The Magneplane system concept definition is constituted of well-defined vehicle, magway and system elements. Previous 1/25th scale modeling successfully demonstrated the baseline concept feasibility for levitation, propulsion and heave control. It is the purpose of the test and development plan described below to test the full capabilities of the proposed system including advanced concepts for integrated vehicle controls, landing gear, magnetic switching and global controls.

In the spirit of preparing the concept for a demonstration project following 5 years of work, we are proposing the following "fast track" development plan incorporating studies, test elements and successive full scale testing leading to completed design and performance specifications as well as operating experience at the completion of the program.

The ultimate goal would be to place MI is a position to bid on, win, install and operate a revenue producing ground transportation system on a scale similar to the proposed Tampa to Orlando high speed ground transportation corridor.

The Plan is presented in 2 parts. Part 1 is a detailed description of generalized development tasks that are relevant to the implementation of any system. This list is not exhaustive but can be combined with similar lists from other SCD and BAA contractors. Work in these areas can be carried out by any qualified vendor.

Part 2 is a description and schedule for three phases of test and development with each phase incorporating more advanced features of the system design concept concluding with a full capability prototype vehicle operating on a closed loop test track achieving the performance specifications.

5.3.9.2. TEST PLAN PARTS

5.3.9.2.a. PART ONE

Through the work of Magneplane and BAA contractors a list of system test needs was developed. Many of the test requirements focused on the deployment of a maglev system in a commercial environment. We list below those test needs that were identified by Magneplane International.

5.3.9.2.a.1. Collision Detection and Avoidance
5.3.9.2.a.2. Fault Tolerant Computer Configuration
5.3.9.2.a.3. System Fault Tree Analysis
5.3.9.2.a.4. System Safety Criteria
5.3.9.2.a.5. Magway Integrity Monitoring
5.3.9.2.a.6. Vehicle Dynamic Sensor Analysis
5.3.9.2.a.7. Development of Scheduling and Routing Algorithms
5.3.9.2.a.8. Evaluation of GPS
5.3.9.2.a.9. Wayside Power System Design for Power Pick-Up
5.3.9.2.a.10. Experimental Validation of Pick-Up Coil Design
5.3.9.2.a.11. Dynamic Power System Analysis
5.3.9.2.a.12. Mech. and Thermal LSM Properties

Description of these tasks appear on the following pages.

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *communication and control*

Subject: *collision detection and avoidance*

Originator: *Magneplane International*

Objective/Justification/Benefits: *An optimized fault-tolerant technique for detecting potential collisions and avoiding them is required. A robust evolved technique will ensure high safety with short headways, which will allow high throughput.*

Programmatic Risk: *medium/high*

Methodology/Approach: *Perform a design analysis and tradeoff studies using various techniques such as radar, acoustics, and IR. Maximum throughput, cost, RMA, and safety are the key variables in the design goals.*

Specific Tasks:

1. *Generate a preliminary technique specification.*
2. *Generate system-level block diagrams and detail operational description with engineering analysis for each technique.*
3. *Perform comprehensive tradeoff studies of the various approaches.*
4. *Generate a summary conclusion, viewgraph presentation and final engineering report.*

Duration: *6 months*
Man-hours: *1000*
Probability of Success: *high*

Commentary: *Raytheon (subcontractor) has extensive related experience and the resources to perform this task.*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *communication and control*

Subject: *fault tolerant computer configurations*

Originator: *Magneplane International*

Objective/Justification/Benefits: *The computer configurations for the vehicle, wayside control, and global control center must be fault-tolerant and satisfy the reliability-maintainability-availability (RMA) requirements. Robust configurations are ultimately essential for passenger safety and optimal operation cost versus benefits. Therefore the configurations must be designed in light of the requirements.*

Programmatic Risk: *medium/high*

Methodology/Approach: *Based on the RMA hardware and software fault tree analysis, an MTBF will be allocated to the hardware and software for the vehicle, wayside, and global control areas. Then, a specific hardware and software concept design will be generated with a detailed analysis showing compliance to RMA requirements.*

Specific Tasks:

1. *Generate a preliminary specification of the hardware/software fault tolerance requirements.*
2. *Generate a hardware/software configuration (with description block diagrams) and an engineering design analysis showing how each approach meets the specification, and the testing required.*
3. *Generate a viewgraph presentation and final engineering report.*

Duration: *8 months*
Man-hours: *1500*
Probability of Success: *high*

Commentary: *Raytheon (subcontractor) has extensive experience in fault tolerant hardware and software design and development.*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *communication and control*

Subject: *system hardware and software fault tree analysis*

Originator: *Magneplane International*

Objective/Justification/Benefits: *The optimal level of redundancy in a control system is the level that meets safety requirements at a minimal cost. We propose to find the optimal fault tolerant/redundant configurations by performing an in-depth system fault tree analysis for both the system hardware and software. The study will provide recommendations for Fail Safe versus False Alarms versus Safety. This task will be used in the evaluation and analysis of the system safety to determine optimal cost versus performance/benefit trade-offs.*

Programmatic Risk: *medium/high*

Methodology/Approach: *Perform a top level analysis to determine a candidate list of hardware and software critical events or combination of events which comprise human safety. Using the candidate list as a baseline, prioritize the events from a cost effectiveness viewpoint for more detailed analysis.*

Specific Tasks: *Using the prioritized list as a baseline, perform safety analysis using an appropriate analysis tool: Fault Tree, MARKOV, FMCA, SNEAK, etc. to provide a recommendation to rectify any problems uncovered.*

Duration: *5 months*
Man-hours: *800*
Probability of Success: *high*

Commentary: *Raytheon has a very experienced and qualified RMA group, which performed similar tasks for large, complex electro/mechanical systems such as Air Traffic Control, Radar Systems, etc.*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *RMA*

Subject: *system safety criteria*

Originator: *Magneplane International*

Objective/Justification/Benefits: *Necessary for any transportation system is a hierarchical set of systems reliability/maintainability/availability/safety (RMAS) criteria, which are used to develop fault tolerant architecture and to suballocate requirements to lower the equipment's redundancy and false alarms, plus provide the optimal cost versus performance trade-off. Therefore we propose to establish the RMAS criteria.*

Programmatic Risk: *medium/high*

Methodology/Approach: *Perform a literature search and internal study to determine a proper (cost effective) set of RMAS requirements/criteria.*

Specific Tasks:

1. *Generate preliminary RMAS specification criteria.*
2. *Generate RMAS trade-off study and analysis.*
3. *Generate a summary viewgraph presentation and final report.*

Duration: *4 months*
Man-hours: *700*
Probability of Success: *high*

Commentary: *Raytheon (subcontractor) has extensive experience and expertise in RMAS requirements definition and trade-off studies performed on other complex electro/mechanical systems.*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *communication and control*

Subject: *magway integrity monitoring*

Originator: *Magneplane International*

Objective/Justification/Benefits: *Maglev requires magway integrity monitoring that is integrated into the control system, so that automatic responses can be made to potential problems before a vehicle is involved. The techniques of building a reliable cost-effective monitoring system must be studied. Therefore, we propose to investigate various techniques and methods of integrating the required level of magway monitoring and integrity checking into the control, communications, and command (C^3) structure.*

Programmatic Risk: *medium*

Methodology/Approach:

1. *Investigate various approaches/techniques of monitoring for magway integrity. Perform an engineering analysis to quantify each selected approach capability.*
2. *Determine the level and location/s of monitoring required to satisfy system safety criteria.*

Specific Tasks:

1. *Generate a preliminary requirements specification on magway integrity and monitoring.*
2. *Perform a trade-off study based on performance vs. requirements vs. cost for several viable schemes.*
3. *Generate various interfacing schemes between monitoring equipment and C^3 equipment.*
4. *Generate a summary viewgraph presentation and final engineering report.*

Duration: *6 months*
Man-hours: *1200*
Probability of Success: *high*

Commentary: *Raytheon has related experience and the engineering resources to perform this task.*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *communication and control*

Subject: *vehicle dynamic sensor development*

Originator: *Magneplane International*

Objective/Justification/Benefits: *Little experience has been accrued on the specific advantages and problems of measuring vehicle clearances, absolute position, velocities and magnetic propulsion fields for maglev. Most data is based on conventional wheeled vehicles or aircraft, data which does not necessarily transfer accurately to maglev. Trade-off studies are required to determine an optimal method of sensing and the extrapolation techniques to reliably derive vehicle data, which will permit the baseline design of the vehicle and magway accessories to yield the most cost effective implementation, specifically tailored for this application. Therefore we propose to develop an implementation for an optimal vehicle dynamics sensor suite, capitalizing on the benefits of the fixed magway constraint, and accommodating the high speed, all-weather environment.*

Programmatic Risk: *Medium to high. Forging a baseline maglev design on a non-optimal sensor suite will impose both cost and performance constraints that will continue to burden the technology once a commitment has been made.*

Methodology/Approach: *To derive vehicle position, velocity, acceleration, clearance from the magway and magnetic propulsion forces, requires a number of different sensors on the vehicle and possible external reference sources on the magway to stimulate those sensors. Appropriate sensor technologies (reflective, RF, mass, vibrating, solid-state, micro-machined and Hall) and ongoing developments in those technologies will be researched and negotiated with the development houses to ascertain potential for this application. A modelling technique will be developed to characterize benefits and interaction opportunities of multiple sensors tolerant to 150 m/sec velocities and operational with water, ice, dust, and air turbulence impediments.*

Specific Tasks:

1. *Identify sensor options and stimulus requirements for five dynamic parameters.*
2. *Negotiate with development houses how these sensors would be adapted to be optimized for this specific application.*
3. *Develop a computer model to permit simulation of vehicle dynamic data accrual with a number of sensors enabling interaction and extrapolation techniques to be evaluated to lead to the optimal sensor suite from performance and cost perspectives.*
4. *Generate a Reference Document to be used as a basis for the maglev prototype development program. Include detailed modelling descriptions and software for future use during system design and development.*

Duration: *9 months*
Man-hours: *1200*
Probability of Success: *High. A structured analysis will reap cost/performance benefits.*

Commentary: *Raytheon (subcontractor) is in a prime position to perform this task, having many year of experience on sensors, including accelerometers, gyros and optical sensors for ballistic missiles, as well as laser gyro and optical/RF radar for a number of development programs. They have the unique position of being expert, but not committed to one (in-house) technology that would bias this type of evaluation and optimization analysis proposed.*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *communication and control*

Subject: *development of scheduling and routing algorithms*

Originator: *Magneplane International*

Objective/Justification/Benefits: *Maglev scheduling and routing algorithm technology, although benefitting from considerable experience accrued from other kinds of traffic systems, has unique aspects that must be considered in the system design. (In particular, speed and routing must be variable in transit and under automatic control.) The SCD contracts, while addressing some of the issues, did not address the evolution of a real and complex multi-vehicle network. It is beneficial at this point in the development (before prototype) to cultivate the global concepts that will permit efficient adaptation into a real network. Therefore we propose to perform decomposition, algorithm development, and trade-offs of the hierarchical autonomous control system.*

Programmatic Risk: *medium/high: Potential exists to develop a system that accommodates the simple processes required to satisfy a prototype configuration, but that is rapidly strangled in the growth of a real and complex network. This must be avoided by ensuring the system concepts are addressed from a global perspective in advance, as a separate program to prototype development.*

Methodology/Approach: *A complex maglev network will be defined and computer modelled to simulate system operation. The research will involve an iterative process of development of algorithms at vehicle, wayside, and global control levels, comparison of traffic flow algorithms, testing under routine, peak, and fault scenarios, and comparison of network configurations.*

Specific Tasks:

1. Define and model a baseline complex network (minimum of 25 magports, 3 global control centers, multiple corridors, 250 vehicles).
2. Model global control scheduling and routing algorithms - both pre-scheduled and dynamically scheduled.
3. Model control algorithms for wayside and vehicle control levels.
4. Integrate models to develop a time coordinated representation of the complex network.
5. Simulate traffic flow in routine, peak, and fault scenarios with a variety of passenger inputs and faults.
5. Iterate and enhance the algorithms, based on results of simulations.
6. Generate a report that details the systems decomposition, based on the complex model simulations, to be applied to the prototype development program. This will include descriptions and software copies of the models for future analysis.

Duration: *12 months*
Man-hours: *8800*
Probability of Success: *medium: This is a complex modelling exercise that has potential for avoiding significant and expensive mistakes in designing the system architecture for maglev. It will require extensive modelling skills and routing/scheduling experience to successfully describe scenarios on a complex network and derive valuable insight that can be used to enhance the controls configuration.*

Commentary: *The extensive experience in air traffic control systems developed by Raytheon (subcontractor), and autonomous controls concepts provides the ideal platform for this significant task in the maglev program.*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *communication and control*

Subject: *evaluation of GPS as a secondary positioning system*

Originator: *Magneplane International*

Objective/Justification/Benefits: *Cost, simplicity, and performance benefits can be realized with GPS - a high-accuracy satellite-based position sensing system. GPS could augment the primary magway-mounted stimuli and on-board vehicle sensing hardware. The specific role of, and need for, GPS must be evaluated. Therefore we propose to evaluate the potential of GPS in maglev.*

Programmatic Risk: *medium/high: Solutions to position sensing of all vehicles in a magway network utilize a stimulus/response approach, requiring regularly distributed stimuli/sensors along the magway, of which are of significant cost. Use of GPS (possibly in combination with less frequent magway markers) will mitigate a significant portion of this cost element as well as simplifying and increasing the reliability of the approach. GPS may also be required in system wake-up.*

Methodology/Approach: *Assess on going and potential enhancements to (differential) GPS in the accuracy, acquisition time and reliability of the hardware. Identify further enhancements specifically beneficial to the maglev system, and evaluate achievable performance, continuity and reliability levels by computer modelling and simulation of different scenarios. Incorporate findings into "Vehicle Dynamics Sensing" analysis and develop recommendation for the GPS role in this technology. Analysis will include GPS as a secondary (primary failure/restart) positioning system, and as an augmentation of the primary system to permit simplifying conventional positioning (distributed) hardware.*

Specific Tasks:

1. Evaluate on going and planned GPS technology developments, with means to improve accuracy and acquisition time.
2. Establish the error models for high speed ground based differential systems, enduring displacement in three dimensions.
3. Develop computer model and perform simulations to determine performance achievable.
4. Negotiate GPS receiver improvements/enhancements targeted at this technology to optimize it for the application and evaluate the system improvements achievable.

Duration: *9 months*
Man-hours: *800*
Probability of Success: *high: At minimum, GPS can provide some degree of secondary positioning data, and a cost-reduction over conventional positioning systems proposed for this technology.*

Commentary: *Raytheon (subcontractor) has developed a conventional GPS receiver and are currently developing a highly integrated advanced GPS receiver, offering minimum acquisition time and differential receiver correlation for improved accuracy. The understanding and in-depth knowledge base generated by these programs at Raytheon offers a unique opportunity to further advance the technology towards the specific requirements of maglev.*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *on-board power*

Subject: *wayside power system design for on-board power pickup*

Originator: *Magneplane International*

Objective/Justification/Benefits: *The wayside power controller must supply an auxiliary power frequency to the LSM for vehicle power pick-up. Appropriate designs for applying the auxiliary power must be investigated.*

Programmatic Risk: *high: Detailed simulation analysis and circuit power system circuit design is required to assure that the auxiliary power frequency for on-board vehicle power can be maintained independently of the propulsion current. (In the Magneplane system, these two currents are applied simultaneously at different frequencies to the LSM winding.)*

Methodology/Approach: *Power circuit analysis will be conducted using circuit analysis simulation tools. Design parameters that will be optimized will be, circuit complexity, component cost, and potential interference between communications systems and the auxiliary power frequencies.*

Specific Tasks:

1. *Identify potential power circuit configurations.*
2. *Perform detailed circuit analysis to identify the size and type of components.*
3. *Estimate costs and potential reliability problems of each approach.*
4. *Select the best power circuit.*
5. *Consider design parameters which may be changed, such as the power system, the auxiliary power frequency.*

Duration: *6 months*
Man-hours: *400*
Probability of Success: *high*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *on-board power*

Subject: *experimental validation of pickup coil design*

Originator: *Magneplane International*

Objective/Justification/Benefits: *Inductive power pickup is a great benefit to maglev, but is an unexplored area. We propose to identify parameters which will help minimize the cost and weight of the inductive power pickup coil, identify the effective design parameters, and validate the pickup coil coupling concepts.*

Programmatic Risk: *medium: Inductive pickup eliminates the auxiliary power units and on board fuel. This dramatically improves the safety and efficiency of the system.*

Methodology/Approach: *A segment of the magway winding and inductive pickup coils will be constructed in their intended curved geometry. These will be wound on forms and constructed in a laboratory fixture where they can be energized and electrical measurements can be made. The results of the measurement will help optimize the winding and coil design and validate the basic approach.*

Specific Tasks:

1. *Design and construct a suitable portion of the magway winding and inductive pickup coil for experimentation.*
2. *Verify mutual inductance calculations by measurement.*
3. *Energize the magway winding and make power transfer measurements to the pickup coil.*
4. *Make temperature rise and cooling measurements of the pickup coil under electrically loaded conditions.*
5. *Measure ac and dc losses in the winding.*

Duration: *4 months*
Man-hours: *400*
Probability of Success: *medium*

Commentary: *May be coordinated with LSM winding tests.*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *propulsion*

Subject: *dynamic power system analysis*

Originator: *Magneplane International*

Objective/Justification/Benefits: *In the Magneplane system, series capacitor compensation circuits must be tuned actively as the vehicle accelerates and decelerates. Simulation studies must be performed to identify suitable choices of active power system components. Schemes to be considered will include switch capacitor banks and active VAR compensators.*

Programmatic Risk: *medium: Effective solutions to this problem will be needed to reduce the overall cost of the system, improve propulsion system performance, and maintain ride quality performance.*

Methodology/Approach: *The solution to this problem will be investigated by using dynamic simulation models which include the effect of vehicle acceleration and deceleration under various grade profiles. Manufacturers of power system components will be contacted to obtain any experience with dynamically tuned equipment. In addition, a literature search will be performed to address identify any published work which has been done to address this issue.*

Specific Tasks:
1. Outline an appropriate dynamic model for the power system.
2. Identify the parameters and parametric ranges for the simulation. These will include grade, acceleration profile, and component tolerances.
3. Design the simulation and perform validation tests.
4. Perform the simulation tests and identify the requirements for power system switching and other component requirements..
5. Perform the literature search.
6. Contact major power component vendors.

Duration: *6 months*
Man-hours: *400*
Probability of Success: *high*

Identification of Maglev Research and Development Projects

R&D Project Serial No.:

Research Area: *propulsion*

Subject: *mechanical and thermal properties of LSM winding design*

Originator: *Magneplane International*

Objective/Justification/Benefits: *To confirm LSM calculations, a length of LSM winding must be built and tested. We propose to identify suitable fabrication methods, design, construct, and then validate the calculated thermal and electrical properties of the LSM winding.*

Programmatic Risk: *high: LSM winding performance is crucial to the reliability of the Magneplane system.*

Methodology/Approach: *Perform detailed thermal and electrical design calculations for the LSM winding. Design a segment of the winding which can be used for electrical testing. Prove out the thermal and electrical design of the winding.*

Specific Tasks:

1. *Perform a detailed thermal, electrical, and mechanical design of the winding.*
2. *Prepare design drawings.*
3. *Have a segment of the winding constructed.*
4. *Perform laboratory testing temperature rise of the winding, dielectric breakdown, magnetic field pattern, inductance.*

Duration: *6 months*
Man-hours: *500*
Probability of Success: *high*

Commentary: *May be coordinated with inductive pickup testing.*

5.3.9.2.b. PART TWO

The following program is a five year plan culminating with complete specifications for building, installing and operating a demonstration maglev transportation system.

The program is broken down into three test phases where each phase incorporates successively more sophisticated elements of the design concept. The theory of the program is to build and operate important elements of the system as quickly as possible in order to shorten the time interval to find and resolve problems.

Analytic study and modeling of the system elements continues in parallel to the experimental effort to help identify problems while simultaneously verifying the codes and predictions through actual measurements.

The ability to produce a convergent technology combining these two efforts is a fundamental principal of the program.

We describe below the program phases:

5.3.9.2.b.1. PHASE 1

Objectives: To accelerate and levitate a test platform using full size superconducting magnet bogies along a 3 km linear test track. See Figure 1.

Detail Test Elements:

Design, build and operate prototype magnet bogies.

Develop and build Linear Synchronous Motor windings.

Specify and procure power conversion electronics for LSM.

Design and build controls and communications for power converter.

Develop and procure on-board attitude, proximity and magnetic field sensors with recording and communicating equipment.

Develop 1st order vehicle controls model for LSM heave damping control.

Obtain test site.

Develop, fabricate and install simplified magway structure.

Detailed Test objectives:

Characterize magnetic lift and drag forces vs. speed.

Measure LSM operating characteristics.

Measure interaction between LSM and on-board magnets.

Test and operate on-board attitude sensors and communications system.

Test simple heave control controls.

Measure vehicle response to controls and magway disturbances.

Demonstrate acceleration/deceleration capability.

Measure power consumption and power disturbances.

Measure test platform structural response.

Study magway loading.

Develop environmental criteria.

Develop design criteria for subsequent phases.

Also see task descriptions for 7 - 24.

Level of Effort:

1 year to prepare.
1.5 years of testing.
Total cost $35.5M.

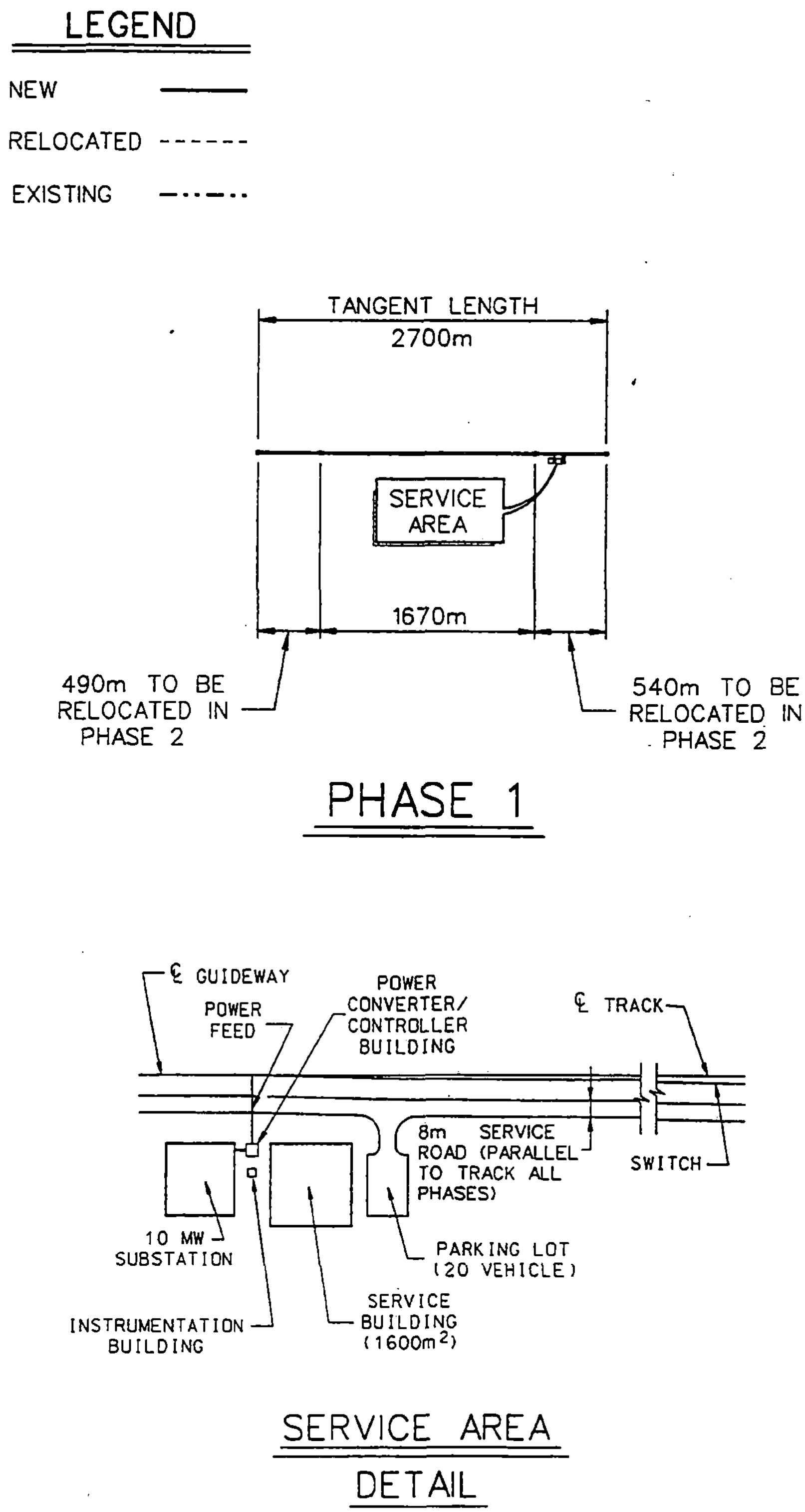


Figure 1 Phase 1 test track

5.3.9.2.b.2. PHASE 2.

Objectives: To develop a test vehicle with "Mark 2" magnet and cryostat design. Incorporating curved and switched magway track features. See Figure 2.

Develop and test landing gear capability.

Detailed Test Elements:

Full sized magnet bogies suspended from simple/lightweight frame.

Mark 2 test magnets.

Advanced cryostat design.

Niobium Tin CICC.

Test magway with curve and switching features.

Multi-block architecture.

LSM controls only.

Prototype landing gear.

Magnetic shielding.

Detailed Test Objectives:

Study and verify magnetic shielding design.

Study landing gear performance and develop design criteria for phase 3 landing gear design.

Test and operate on-board attitude sensors and communications system.

Test advanced heave control model.

Measure vehicle response to controls and magway disturbances.

Test performance under various environmental conditions.

Develop design criteria for phase 3.

See tasks 31-55.

Level of Effort:

2.5 years to prepare.
1 year of testing.
Total cost $29.8M.

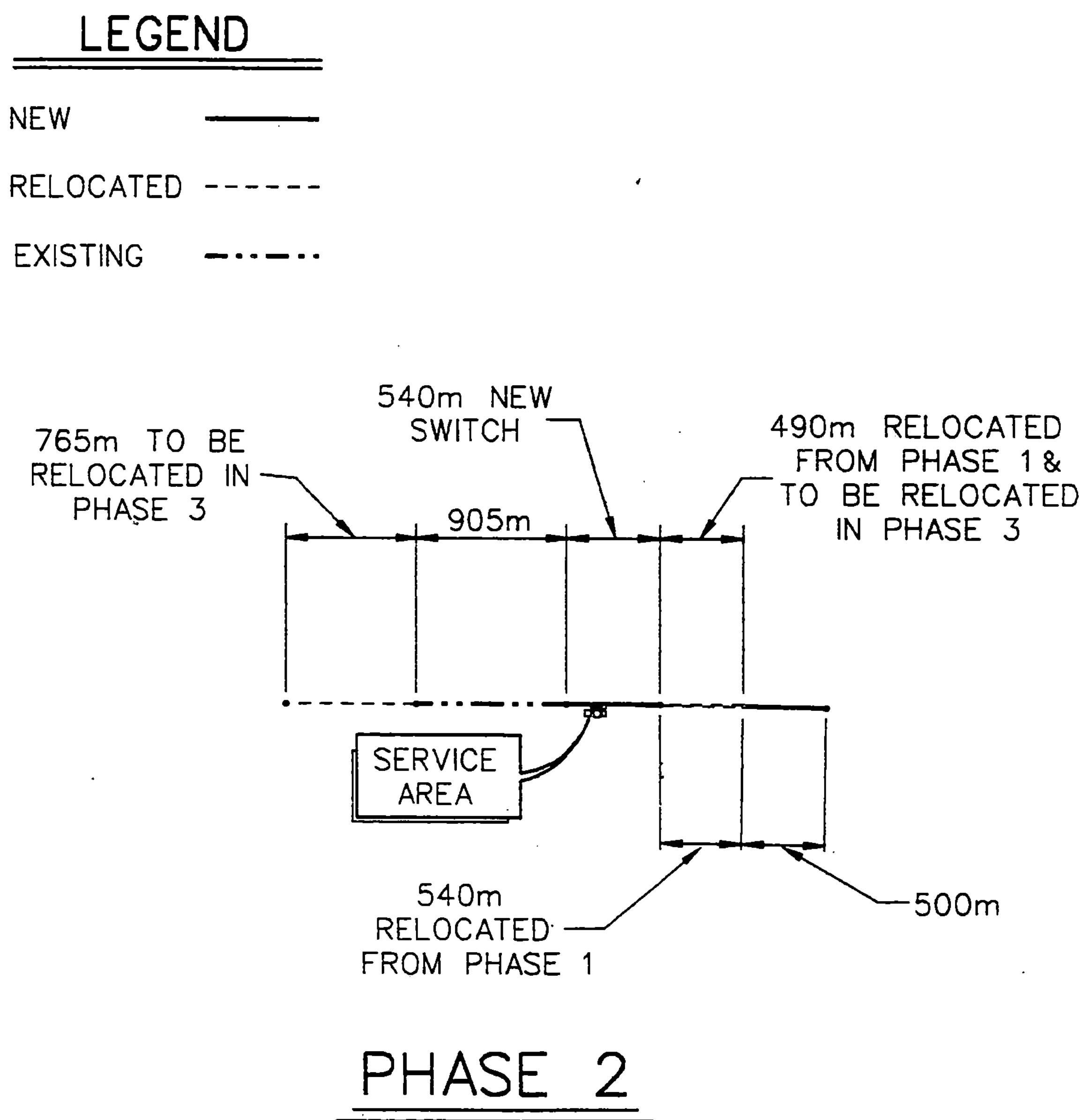


Figure 2 Phase 2 test track

5.3.9.2.b.3. PHASE 3.

Objectives: To develop a fully functional prototype vehicle and operate on a closed loop test track. See Figure 3.

Complete design and specifications for all aspects of system design and operation.

Detailed Test Elements:

Full prototype vehicle.

Full capability test magway with loop structure.

Full C^3 system.

Detailed Test Objectives:

Verify vehicle performance
- ability to achieve design speeds
- acceleration rates
- deceleration rates, normal braking
- deceleration rates, emergency braking
- curve and magswitch performance

Measure ride quality and identify needs for improvement

Refine magnetic shielding methods.

Measure electrical power requirements and identify needs for improvement.
- vehicle on-board power consumption
- vehicle propulsion power consumption

Quantify vehicle dynamic parameters and identify need for improvement
- structural frequencies and damping
- aerodynamic coefficients
- control surface loading and control power needs

Collect performance parameters of individual subsystems which provide a basis for improving systems performance.
- cryogenic system
- vehicle control system
- stability augmentation system
- power conversion system
- environmental system

Demonstration of vehicle compliance with Federal regulations for passenger carriage.

Implement on-board power pick-up, battery backup and power distribution design.

Implement advanced LSM and magway design.

Implement global controls and develop controls strategies.

Perform endurance testing of all systems.

See tasks 62-89.

Level of Effort:

2.5 years to prepare.
2 years of testing.
Total cost $105.6M.

$55,000,000 / 8764 m = 6.3 $/km

6.3 $/km · km/.62 mi = $10 M/mile

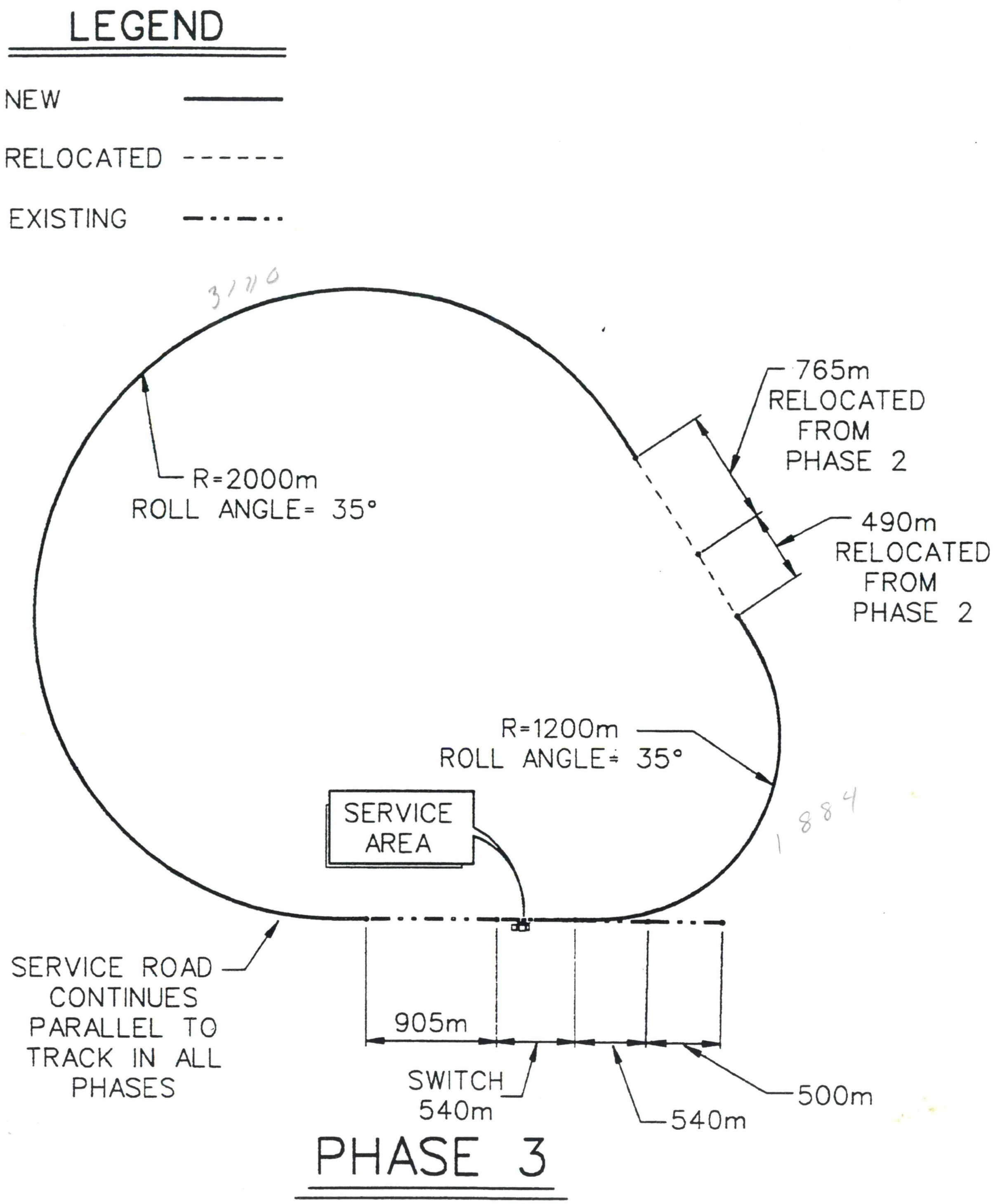
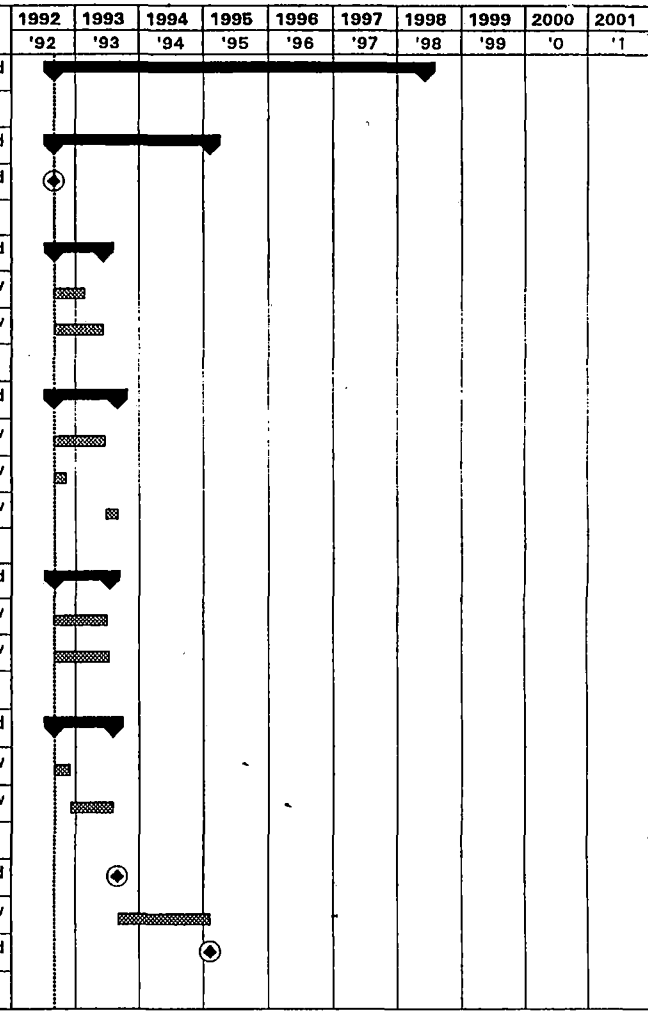


Figure 3 Phase 3 test track

5.3.9.2.b.3. DEVELOPMENT SCHEDULE

The following pages show the schedule for the three phases of the development plan. Budget estimates are made for each task and bar charts are included showing the timing of the monies spent on each phase. Finally each program task is described.

ID	Name	Total Cost	Start	Duration
1	Five Year Development Plan	$171,014,000	1 Sep '92	1505d
2				
3	Phase I	$35,551,000	1 Sep '92	635d
4	Start Phase I	$0	1 Sep '92	0d
5				
6	Controls and Communications	$290,000	1 Sep '92	200d
7	Prelim. Heave Control Model	$40,000	1 Sep '92	25w
8	Develop Sensor and Comm Platform	$250,000	1 Sep '92	40w
9				
10	Vehicle	$7,100,000	1 Sep '92	260d
11	Develop Mark 1 Magnet Modules	$6,200,000	1 Sep '92	42w
12	Design Platform, Mech	$100,000	1 Sep '92	10w
13	Assemble Test Platform	$800,000	22 Jun '93	10w
14				
15	Electrification	$10,100,000	1 Sep '92	225d
16	Develop LSM and Power Conversion	$10,000,000	1 Sep '92	43.4w
17	Site Electric Design and Construction	$100,000	1 Sep '92	45w
18				
19	Guideway	$16,060,000	1 Sep '92	240d
20	Design Guideway	$60,000	1 Sep '92	13w
21	Site and Build Test Track	$15,000,000	1 Dec '92	35w
22				
23	Begin Test Lin. Vehicle	$0	30 Aug '93	0d
24	Linear Vehicle Test Program	$2,000,000	31 Aug '93	75w
25	End Phase I	$0	6 Feb '95	0d
26				

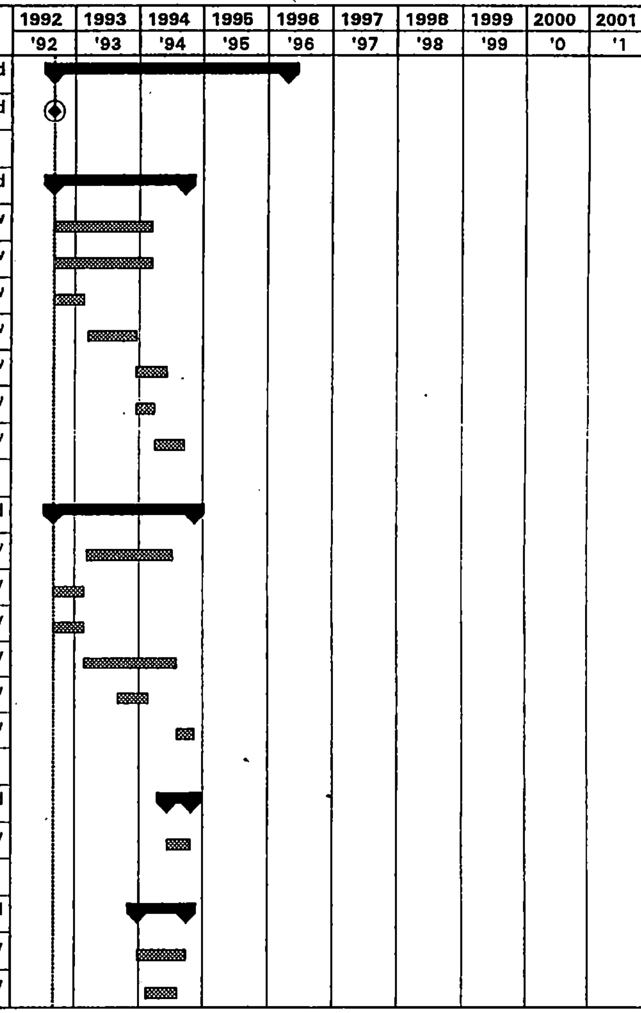


Project: Prepare for Prototype Test
Date: 27-8-92

Critical · Noncritical · Progress · Milestone · Summary · Rolled Up

Page 1

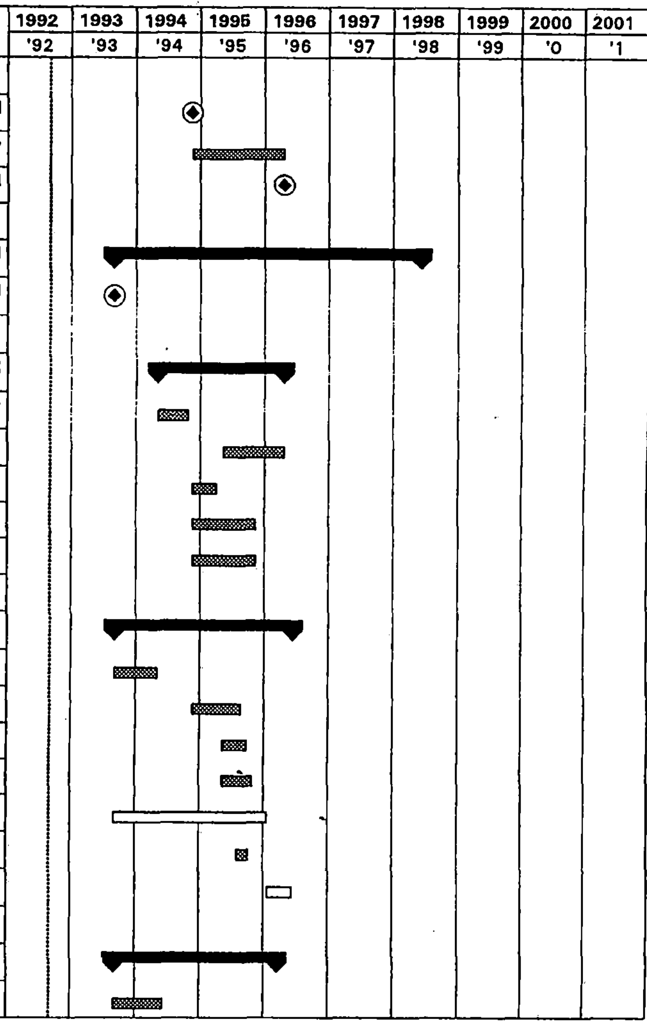
ID	Name	Total Cost	Start	Duration
27	Phase II	$29,811,000	1 Sep '92	950d
28	Start Phase II	$0	1 Sep '92	0d
29				
30	Controls and Communication	$2,510,000	1 Sep '92	535d
31	6 DOF Model	$220,000	1 Sep '92	80w
32	Magnetic Field Analysis	$1,450,000	1 Sep '92	80w
33	Heave Control Model	$40,000	1 Sep '92	25w
34	Switch Modeling	$100,000	16 Mar '93	40w
35	Block Controls with Handoff	$100,000	14 Dec '93	25w
36	Advanced On-Board Sensors	$500,000	14 Dec '93	15w
37	Assemble Sensor Hardware	$100,000	29 Mar '94	25w
38				
39	Vehicle	$10,300,000	1 Sep '92	575d
40	Mark 2 Magnet Bogie	$5,900,000	9 Mar '93	70w
41	H-Pad Development	$350,000	1 Sep '92	25w
42	A-Pad Development	$350,000	1 Sep '92	25w
43	Gear Development	$1,200,000	23 Feb '93	75w
44	Design and Fab Shielding	$500,000	31 Aug '93	25w
45	Update Test Platform	$2,000,000	2 Aug '94	15w
46				
47	Electrification	$2,000,000	7 Jun '94	100d
48	Add 2 Block Hardware and Controls	$2,000,000	7 Jun '94	20w
49				
50	Guideway	$10,000,000	21 Dec '93	200d
51	Mag Switch Des./Construction	$4,000,000	21 Dec '93	40w
52	Design and Build Curve	$6,000,000	8 Feb '94	26w



Project: Prepare for Prototype Test
Date: 27-8-92

Critical | Progress | Summary
Noncritical | Milestone | Rolled Up

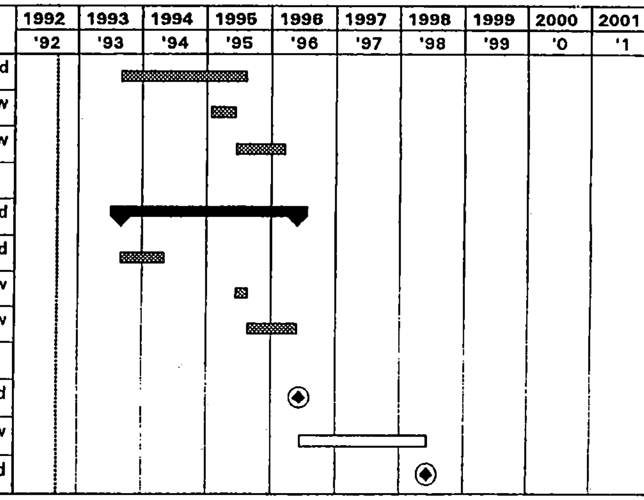
ID	Name	Total Cost	Start	Duration
53				
54	Begin Test Adv. Linear Vehicle	$0	14 Nov '94	0d
55	Advanced Linear Vehilce Test	$5,000,000	15 Nov '94	75w
56	End Phase II	$0	22 Apr '96	0d
57				
58	Phase III	$105,651,000	30 Aug '93	1245d
59	Start Phase III	$0	30 Aug '93	0d
60				
61	Controls and Comm.	$2,050,000	3 May '94	515d
62	Aero-Controls Design	$100,000	3 May '94	25w
63	Integrated Attitude Controls/Flight Contr	$350,000	9 May '95	50w
64	Full On-Board Communications	$100,000	15 Nov '94	20w
65	Route Model	$1,000,000	15 Nov '94	52w
66	Global Controls, Spec and Procure	$500,000	15 Nov '94	52w
67				
68	Vehicle	$22,150,000	31 Aug '93	725d
69	Aero Characterization of Vehicle	$100,000	31 Aug '93	35w
70	Power Pick-Up Design, Fab	$400,000	15 Nov '94	40w
71	On-Board Power Sys. Des./Fab.	$200,000	9 May '95	20w
72	On-Board Systems Design	$250,000	9 May '95	25w
73	Vehicle Fuselage	$20,000,000	31 Aug '93	125w
74	Verify Vehicle Structure	$200,000	1 Aug '95	10w
75	Assemble Full Capability Prototype	$1,000,000	23 Jan '96	20w
76				
77	Electrification	$16,240,000	31 Aug '93	665d
78	Dynamic Power System Modeling	$70,000	31 Aug '93	40w



Project: Prepare for Prototype Test
Date: 27-8-92

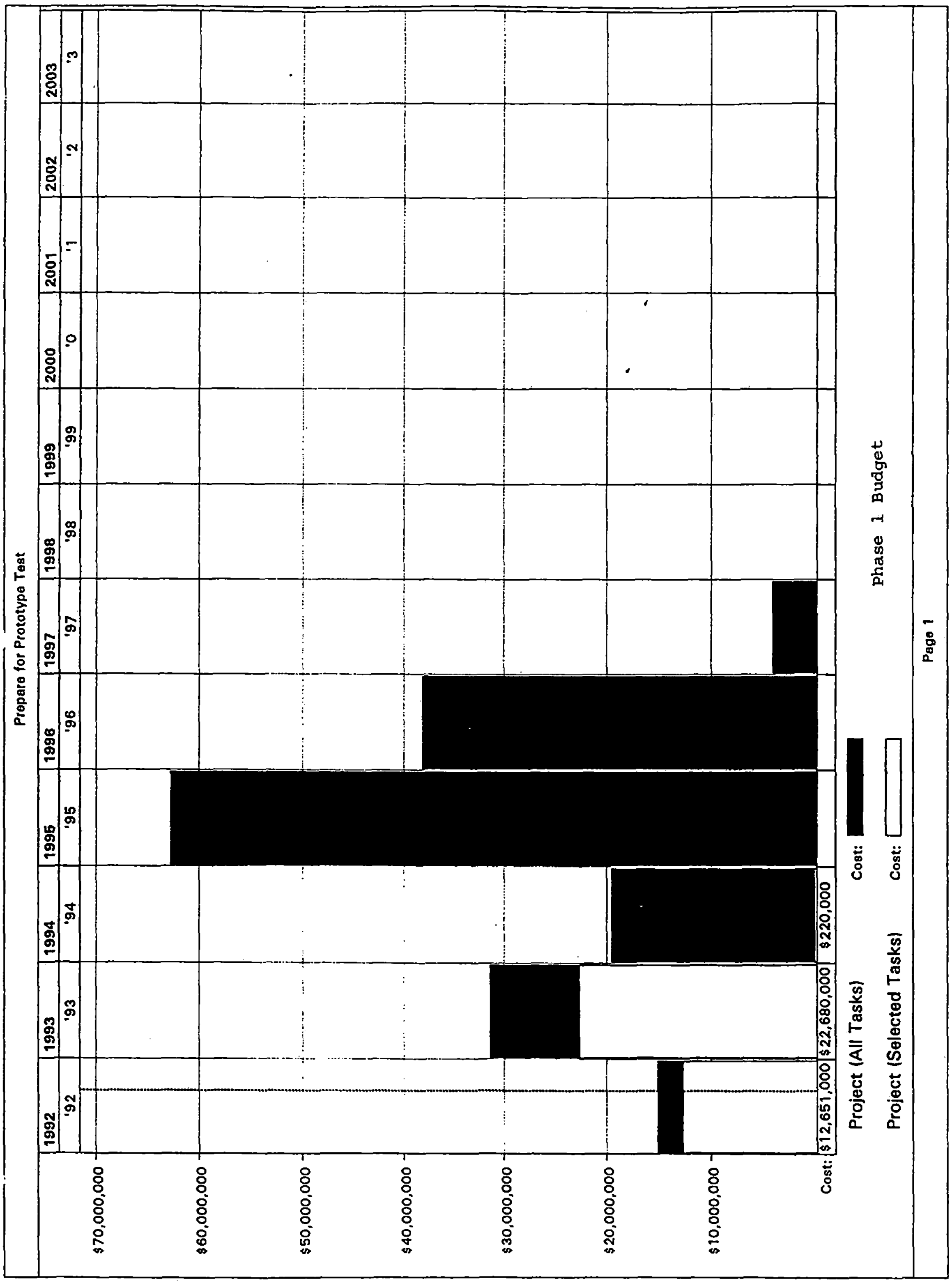
Critical | Progress | Summary
Noncritical | Milestone | Rolled Up

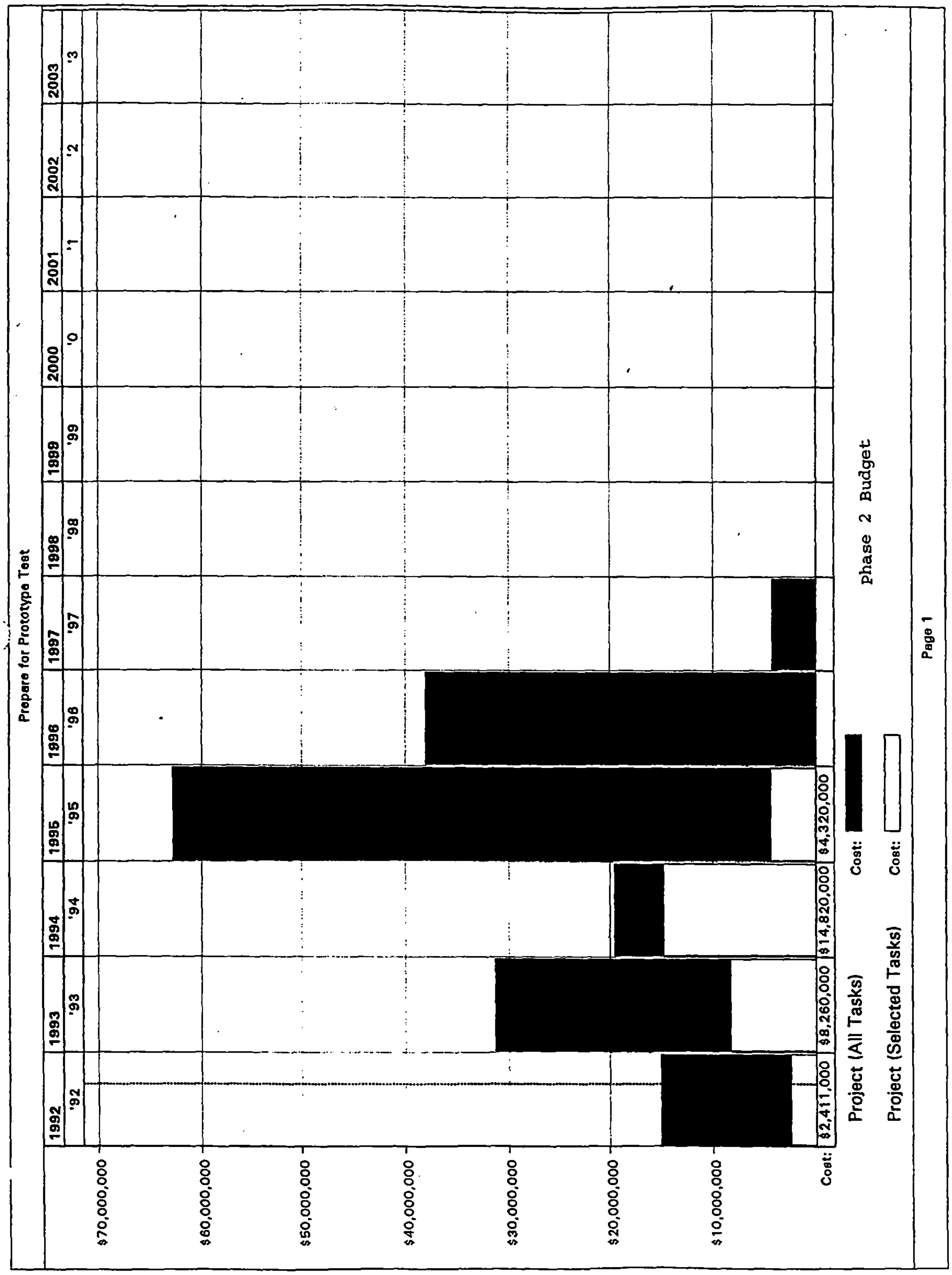
ID	Name	Total Cost	Start	Duration
79	Mechanical and Thermal LSM Study	$100,000	31 Aug '93	510d
80	Advanced LSM Design	$70,000	24 Jan '95	20w
81	Advanced LSM Fab and Install	$16,000,000	13 Jun '95	40w
82				
83	Guideway	$55,210,000	31 Aug '93	715d
84	Lev. Plate Thermal Model	$140,000	31 Aug '93	175d
85	Box Beam Construction Methods	$70,000	13 Jun '95	10w
86	Full Capability Test Track	$55,000,000	22 Aug '95	40w
87				
88	Begin Prototype Vehicle Test	$0	10 Jun '96	0d
89	Vehicle Test Program	$10,000,000	11 Jun '96	104w
90	End Phase III	$0	8 Jun '98	0d

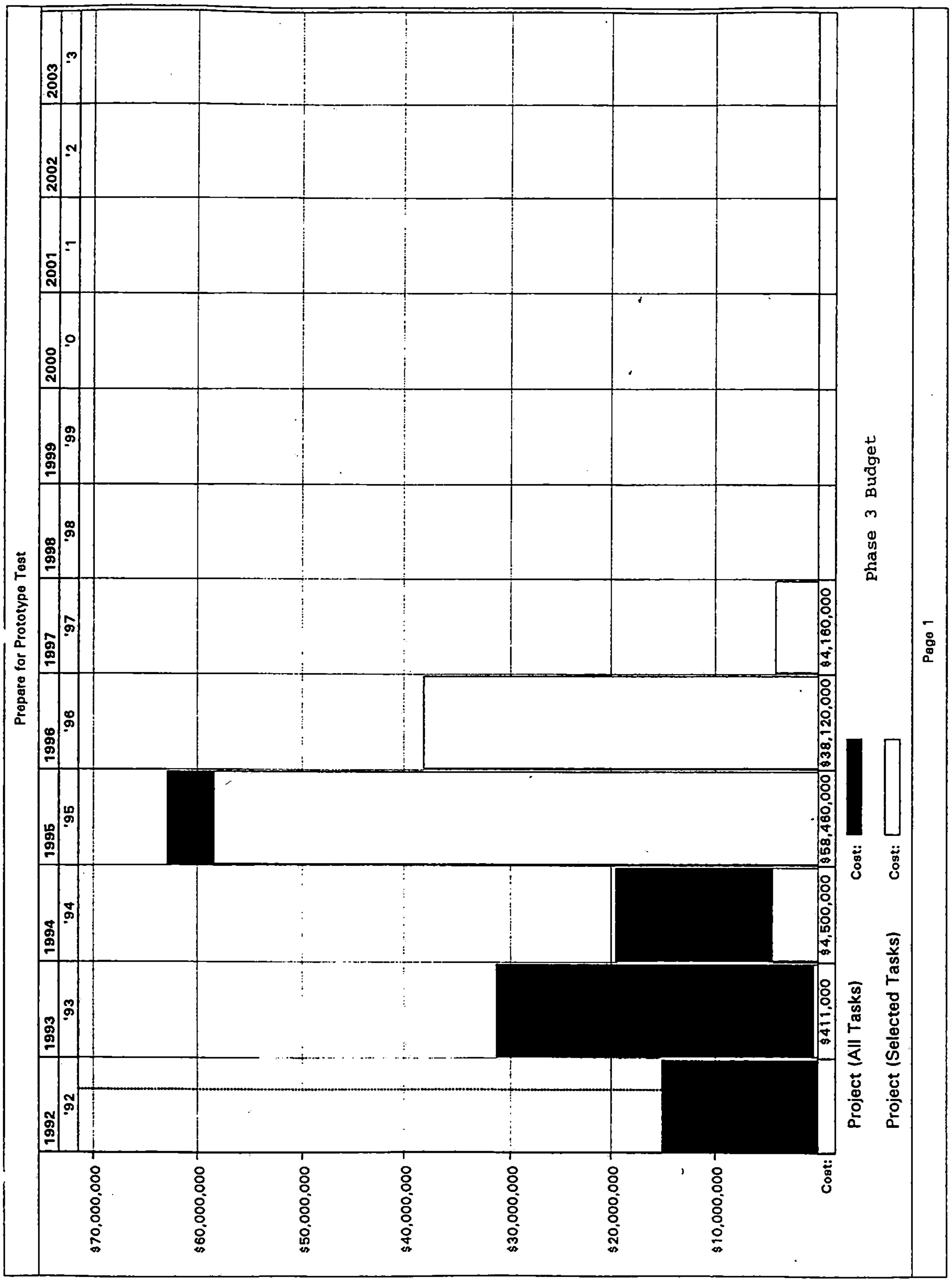


Project: Prepare for Prototype Test
Date: 27-8-92

Critical | Progress | Summary
Noncritical | Milestone | Rolled Up


Prepare for Prototype Test
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
'92
'93
'94
'95
'96
'97
'98
'99
'0
'1
'2
'3
$70,000,000
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
Cost:
$12,651,000
$22,680,000
$220,000
Project (All Tasks)
Cost:
Project (Selected Tasks)
Cost:
Phase 1 Budget
Page 1


Prepare for Prototype Test
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
'92
'93
'94
'95
'96
'97
'98
'99
'0
'1
'2
'3
$70,000,000
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
Cost:
$2,411,000
$8,260,000
$14,820,000
$4,320,000
Phase 2 Budget
Project (All Tasks)
Cost:
Project (Selected Tasks)
Cost:
Page 1


Prepare for Prototype Test
1992
'92
1993
'93
1994
'94
1995
'95
1996
'96
1997
'97
1998
'98
1999
'99
2000
'0
2001
'1
2002
'2
2003
'3
$70,000,000
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
Cost:
$411,000
$4,500,000
$58,460,000
$38,120,000
$4,160,000
Project (All Tasks) Cost:
Project (Selected Tasks) Cost:
Phase 3 Budget
Page 1

5.3.9.2.b.4. TASK DESCRIPTIONS

Task 7: PRELIMINARY HEAVE CONTROL MODEL

Objective: Develop control algorithm and specify Power Converter control hardware for 1st order heave damping for the Phase I test program.

Risk: Low

Specific Tasks:

1. Develop characteristics for the LSM winding, on-board propulsion magnets and power conversion equipment.

2. Identify the parameters and parametric ranges for the simulation, including heave control range and frequency, LSM modes, vehicle speed.

3. Determine input sensor requirements.

4. Create LSM control model.

5. Predict control action vs. disturbances and project power converter, LSM and vehicle response. Perform validation tests.

6. Revise specifications for power converter and power converter controls hardware.

Task 8: DEVELOP SENSOR AND COMMUNICATIONS PLATFORM

Objective: Specify, procure and make ready for installation requisite on-board sensor hardware, communications and recording gear to perform phase I testing. Also included is communications buffer to Power Converter Controls.

Risk: Low

Specific Tasks:

1. Develop specifications and procure on-board 6 DOF accelerometers.

2. Develop specifications and procure on-board proximity sensors.

3. Develop specifications and procure on-board magnetic field sensors.

4. Develop specification and procure on-board vehicle position sensors.

5. Create on-board sensor platform including power supply, communication buffer, communication RF link and data recording device.

6. Specify and procure wayside communications receiver and interface to wayside power controller.

TASK 10: DEVELOP MARK 1 MAGNET BOGIES

Objective: Specify, procure and/or fabricate Mark 1 magnet bogies for phase I levitation and propulsion.

Risk: Low

Specific Tasks:

1. Design the NbTi internally cooled conductor based on available superconducting billets. Choose a sheath approach.

2. Design the persistent operation mechanical switch and thermal switch; design the retractable leads.

3. Modify the cryostat design from the SCD to accommodate a lead and switch extension.

4. Produce the fabrication drawings for the coils, cryostats and auxiliary components.

5. Interface with cryogenic systems contractor.

6. Interface with Magneplane Int. systems integration activities.

7. Test the persistent operation of mechanical switch and thermal switch components.

8. Test the conductor terminal details.

9. Fabricate conductor.

10. Fabricate the levitation and propulsion coil forms.

11. Fabricate the eight levitation and twelve propulsion coils (wind, impregnate).

12. Fabricate the four levitation and two propulsion cryostats (shields, vacuum chamber, cold-mass supports, lead extensions).

13. Fabricate the auxiliary components (six persistent switches, six disconnectable leads, six hydraulic manifolds, lead towers, power supplies). The Mark 1 system will run all the coils in each module in series, rather than using the independent coil approach adopted for safety reasons in the SCD.

14. Assemble the levitation and propulsion modules.

15. Cold test the levitation and propulsion modules in their respective cryostats.

16. Design and build suspension points for installation into the test vehicle.

Comments:

NbTi SC magnets will not be as tolerant to magway perturbations as will be Nb3Sn.

TASK 11: DESIGN PLATFORM

Objective: Design and fabricate a test platform capable of mounting magnet bogies and cryostats, attitude sensors, communications and recording instrumentation, low speed landing gear and brakes for phase 1 testing.

Risk: Medium

Specific Tasks:

1. Develop specifications for size, loads and structural stiffness and frequencies to perform linear high speed test with full sized magnet bogies.
2. Develop specifications for environmental protection for on-board gear. Define sizes and locations for required on-board gear including cryogenic cooling system, sensors, instruments, communications and safety equipment.
3. Develop specifications for on-board power and cryogenic fluids.
4. Develop specifications for vehicle handling both in and out of service.
5. Design electrical, mechanical and cryogenic on-board systems.
6. Design platform.

TASK 12: ASSEMBLE TEST PLATFORM

Objective: Fabricate and assemble test platform.

Risk: Medium

TASK 16: DEVELOP LSM AND POWER CONVERSION

Objective: Specify, procure and/or fabricate and install materials for phase 1 power conversion and LSM.

Risk: Medium

Specific Tasks:

1. Develop specification for power converter and controls for phase 1 operation.
2. Purchase and install power conversion equipment.
3. Design phase 1 LSM winding.
4. Procure and test sample lengths of LSM. Perform laboratory testing for temperature rise of winding, dielectric breakdown, magnetic field pattern and inductance.
5. Procure and install phase 1 LSM.

TASK 17: SITE ELECTRIFICATION

Objective: Develop specifications and contract work to bring adequate utility power to the test site.

Risk: Low

Specific Tasks:

1\. Develop electrification requirements.

2\. Determine local availability of power.

2\. Obtain necessary permits.

3\. Install feeder lines and substation equipment.

TASK 20: DESIGN TEST MAGWAY

Objective: Develop phase 1 civil magway specifications.

Risk: Low

Specific Tasks:

1. Review SCD design specifications for applicability to phase 1 test program.
2. Define optimal support spacing. Analyze thermal and weather issues.
3. Develop levitation beam design. Design magway mounts and LSM mounting details.
4. Work with vendors to optimize design to be consistent with cost and timing objectives.
5. Define loading to foundations, design cost effective footings consistent with loading and site conditions.
6. Design supports for box beams.

TASK 21: SITE AND BUILD TEST TRACK

Objective: Fabricate and install magway for phase 1 test.

Risk: Low

Specific Tasks:

1. Perform geotechnical investigation and design foundations. Obtain survey.
2. Obtain necessary permits.
3. Construct access roads, etc.
4. Construct magway foundations.
5. Construct and electrify magway.
6. Design and install site service area and buildings.

TASK 31: 6 DOF MODEL.

Objective: Assess vehicle behavior over the full operating envelope, including curved magway and magnetic switches.

Calculate vehicle dynamic response, model control requirements for both LSM and aero controls, optimize performance and identify critical situations.

Risk: Low

Specific Tasks:

1. Create a 6 DOF time-domain computer simulation model of the Magneplane incorporating:

   non-linear aerodynamic performance of the vehicle control surfaces
   LSM control authority
   non-linear magnetic forces
   multi-input/output linear state-space controller

2. Model input disturbances such as magway curves, roughness and wind gusts/turbulence.

3. Assess performance over the complete range of vehicle speed and disturbance characteristics, including switching.

4. Assess take-off and landing performance.

5. Assess performance in emergency situations.

6. Model sensor and control actuator dynamics.

7. Model 1st order vehicle flexibility.

8. Optimize control system based on performance assessments.

9. Evaluate controller and system fault tolerance.

TASK 32: MAGNETIC FIELD ANALYSIS

Objective: Electromagnetic and Dynamic Modeling of the magplane/magway system providing detailed dynamic inputs to 6 DOF model, environmental magnetic field analysis and shielding design analysis.

Risk: Medium

Specific Tasks:

1. Develop tools for the modeling of magnetic fields and eddy currents in the presence of static and moving conductors.

2. Calculate forces and moments produced on magnets by various motions and attitudes with respect to straight, curved, transition sections and switch sections of magway.

TASK 33: HEAVE CONTROL MODEL

Objective: Develop heave control model for integration into full 6 DOF modeling effort.

Develop control algorithm allowing stable operation in straight, curved and switched magway operation.

Risk: Medium

Specific Tasks:

1. Develop characteristics for the LSM winding, on-board propulsion magnets and power conversion equipment.

2. Identify the parameters and parametric ranges for the simulation, including heave control range and frequency, LSM modes, vehicle speed.

3. Determine input sensor requirements.

4. Analyze phase 1 performance.

5. Update LSM control model.

6. Predict control action vs. disturbances and project power converter, LSM and vehicle response. Perform validation tests.

7. Develop revised control algorithm and revise specifications for power converter and power converter controls hardware.

TASK 34: SWITCH MODELING

Objective: Provide detailed understanding of dimensional requirements of magswitch, transitions from mainline magway, ride quality constraints and safety issues.

Risk: High

Specific Tasks:

1. Perform electromagnetic analyses to optimize geometry of switching coils and the magway geometry through the switch and in transitions from the mainline. Calculate electromagnetic loads and spring constants for use in dynamic analysis of vehicle as it traverses switch.

2. Establish the LSM propulsion operation concept through the switch and establish geometric power requirements.

3. Determine limitations on switch geometry and dimensions imposed by electromagnetic, propulsion and ride quality requirements by using a dynamic model of the vehicle.

4. Carry out a preliminary design of the switch electrical, mechanical and construction features.

5. Perform a safety analysis of switch operations.

TASK 35: BLOCK CONTROLS WITH HANDOFF

Objective: Develop control methods for transfer of vehicle between electrified control blocks.

Risk: Low

Specific Tasks:

1. Develop algorithms for vehicle transfer between control blocks.

2. Test performance with 6 DOF dynamic model.

3. Specify control inputs and additional power conversion control hardware and software needed.

TASK 36: ADVANCED ON-BOARD SENSORS

Objective: Determine the optimal method of sensing and extrapolation techniques to reliably derive vehicle data, accommodating the high speed, all weather environment.

Risk: Medium to High

Specific Tasks:

1. Identify sensor options and stimulus requirements for five dynamic parameters.

2. Develop and adapt sensors for this application.

3. Develop computer model to permit simulation of vehicle dynamic data accrual with a number of sensors enabling interaction and extrapolation techniques to be evaluated to lead to the optimal sensor suite from performance and cost perspectives.

TASK 37: ASSEMBLE SENSOR HARDWARE

Objective: Procure and ready for installation advanced sensor suite.

Risk: Low

Specific Tasks:

1. Procure sensor hardware.

2. Design and fabricate. sensor platforms, power supplies and communications equipment.

3. Test and verify performance of assembly.

TASK 40: MARK 2 MAGNET BOGIES

Objective: Develop and build "mark 2" magnet bogies with Nb3Sn CICC superconducting wire cooled with super-critical helium.

Full implementation of advanced cryogenic system and cryostat configuration.

Risk: Medium

Specific Tasks:

1. Finalize the CDS design for the Mark 2 on-board systems.
2. Design the transformer induction unit, assumed to be a 10 coil unit which will energize one bogie at a time.
3. Produce the fabrication drawing for the coils, cryostat, and auxiliary components for the on-board and induction modules.
4. Interface with MI systems integration activities.
5. Develop a persistent joint for Nb3Sn cable.
6. Test the conductor termination details.
7. Fabricate and test two levitation coils in the induction mode in an existing test cryostat. Using a variable temperature helium source, establish the energy margin as a function of temperature. Use one of the coil pairs as a disturbance source.
8. Fabricate conductor.
9. Fabricate the eight levitation and 12 propulsion coil forms and coils (wind, heat treat, impregnate).
10. Fabricate the four levitation and two propulsion cryostats (shields, vacuum chamber, cold-mass supports), or modify the Mark 1 systems if no longer in service. The cost estimate assumes new cryostats.
11. Fabricate the auxiliary components (six persistent joints, six hydraulic manifolds).
12. Assemble the levitation and propulsion modules.
13. Cold test the levitation and propulsion modules.
14. Fabricate the Nbti conductor for induction charging unit.
15. Fabricate the 10 induction coils needed to energize one complete bogie.

16. Fabricate the induction system cryostat of cryostats depending on the design concept (shields, vacuum chamber, cold-mass supports).

17. Fabricate the auxiliary components (three persistent joints, three hydraulic manifolds, disconnect leads). The power supplies from the Mark 1 system are assumed to be available.

18. Assemble the induction system.

19. Cold test the induction system and charge the Mark 1 or Mark 2 system.

TASK 41: H-PAD DEVELOPMENT

Objective: Develop and test materials for the emergency brake skids.

Risk: High

Specific Tasks:

1. Build a test environment which would allow tests on small pads at up to 150 m/sec on aluminum and paving at pressures of 35 - 70 kN/m^2, using a .7 m aluminum drum and large lathe.

2. Test multiple materials to determine optimal composition.

3. Build a test environment for full size pads using a 1-2 m rotary table with a slot to simulate the magway joints.

4. Test the final material for rate of wear (pads and surface), coefficient of friction, performance on wet or contaminated surfaces and heating (pad and surface).

TASK 42: A-PAD DEVELOPMENT

Objective: Develop and test materials and methods for air bearing skids for landing gear use.

Risk: High

Specific Tasks:

1. Build a test environment which would allow test on small pads at up to 150 m/sec on aluminum and paving at pressures of 35 - 70 kN/m^2, using a .7 m aluminum drum and a large lathe. (Automatic advance would provide enough thermal isolation to simulate real magway.)

2. Test multiple materials with and without air flow to determine optimal composition.

3. Build a test environment for full size pads using a 1-2 m rotary table with a slot to simulate the magway joints.

4. Test the final material for rate of wear, coefficient of friction (with and without airflow), heating, performance under various surface conditions and required air flow.

TASK 43: LANDING GEAR DEVELOPMENT

Objective: Develop and test hardware for the vehicle landing gear.

Risk: High

Specific Tasks:

1. Develop specifications for emergency brakes and landing skids.
2. Design and fabricate test article for landing gear including basic deployment method, surface articulation and air supply.
3. Develop a test fixture allowing realistic test environment.
4. Test and validate design concept at operational pressure, velocity and duty cycle.
5. Write complete design spec for landing gear for phase 3 test vehicle.

TASK 44: SHIELDING DESIGN AND FABRICATION

Objective: Develop and construct shielding coils capable of reducing stray field near the superconducting magnet bogies to acceptable environmental limits for long term exposure.

Risk: Medium

Specific Tasks:

1. Evaluate SCD shielding concept.
2. Develop preliminary design for shielding coils.
3. Model stray fields and field reductions due to proposed shielding concepts.
4. Develop coil structure and specify power supply requirements.
5. Design and fabricate shielding coils.

TASK 45: UPDATE TEST PLATFORM

Objective:

Update test platform to include provisions for landing gear, Mark 2 magnet equipment and active magnet shielding coils.

Risk: Medium

TASK 48: ADD TWO BLOCK HARDWARE AND CONTROLS

Objective: Install hardware and software for phase 2 testing with two electrified blocks.

Risk: Low

Specific Tasks:

1. Spec, procure and install second power converter with cables, switchgear, etc.
2. Spec, procure and install additional controls and communication hardware.
3. Develop and install additional controls software.

TASK 51: MAGSWITCH DESIGN AND CONSTRUCTION

Objective: Design, fabricate and install magswitch.

Risk: Medium

Specific Tasks:

1. Develop specifications for magswitch LSM and steering coils.

2. Develop specifications for magswitch LSM power converter and switches.

3. Design, construct and install magswitch civil structure.

   a. Determine switch geometry after verifying design speed and allowable ride quality.
   b. Design aluminum box beams including transition sections.
   c. Select and detail filler material.
   d. Design supports and foundations.
   e. Construct foundations and supports.
   f. Fabricate, deliver and install box beams.
   g. Align magway and install filler material.

4. Design, fabricate, construct, install and align magswitch civil structure.

5. Fabricate, procure and install electrical and control components.

TASK 52: DESIGN AND BUILD CURVE

Objective: Design, fabricate and install curve for phase 2 testing.

Risk: Medium

1. Verify vehicle loading to magway for coordinated and uncoordinated banking.

2. Verify gap between levitation plates, i.e. width of LSM windings.

3. Calculate spiral transition and determine method of constructing spiral and curve.

4. Design box beams for loading and configuration determined in tasks 1-3 above. Verify optimal span length.

5. Design end supports and foundations for box beams.

6. Construct foundations and end supports.

7. Fabricate, deliver, install and align box beams and LSM windings.

TASK 62: AERO-CONTROLS DESIGN

Objective: Select optimum configuration for the aerodynamic control surfaces and characterize control forces generated.

Risk: Low

Specific Tasks:

1. Select control surface authorities for all required degrees of freedom.
2. Optimize surface size, shape and location while minimizing cross coupling.
3. Perform wind tunnel testing to verify design.
4. Estimate control power required for surface control.

TASK 63: INTEGRATED ATTITUDE CONTROLS DESIGN

Objective: Assess the effects of combining all the vehicle dynamic response controls and determine the optimum combination of sensors to provide robust control. Assess the effects of vehicle flexibility of the attitude control design.

Risk: Medium

Specific Tasks:

1. Select combinations of sensor inputs to control algorithm.
2. Specify redundancy required.
3. Develop stability algorithm.
4. Test controls strategy on vehicle dynamic simulator.

TASK 64: FULL ON-BOARD COMMUNICATIONS

Objective: Develop specifications and procure on-board communications and control package.

Risk: Medium

Specific Tasks:

1. Analyze performance of phase 1 communications and control system.

2. Specify and procure full communications and control hardware.

3. Specify and fabricate mounting, power supply and environment for communications and controls.

TASK 65: ROUTE MODEL

Objective: Develop algorithms and trade-offs for the hierarchical autonomous control system.

Risk: Medium to High

Specific Tasks:

1. Define and model a baseline network.

2. Model global control scheduling and routing algorithms - both pre-scheduled and dynamically scheduled.

3. Model control algorithms for wayside and vehicle control levels.

4. Integrate models to develop a time coordinated representation of the network.

5. Simulate traffic flow in routine, peak and fault scenarios.

6. Iterate and enhance the algorithms, based on results of simulations.

TASK 66: GLOBAL CONTROLS SPEC AND PROCURE

Objective: Specify and procure global command and control center.

Risk: Low

TASK 69: AERO CHARACTERIZATION OF VEHICLE

Objective: Determine the aerodynamic properties of vehicle and control surfaces.

Risk: Medium

Specific Tasks:

1. Optimize the vehicle aerodynamic properties with respect to reducing drag, control surface effectiveness, favorable ground effect, reduced sensitivity to side winds, gusts, vehicle passage, tunnel entry and flow control for minimum noise generation.

2. Perform wind tunnel test to validate and compliment the computational fluid dynamic studies.

TASK 70: POWER PICK-UP DESIGN AND FABRICATION.

Objective: Design, fabricate and install on board power pick-up coils.

Risk: Medium

Specific Tasks:

1. Design and construct a suitable portion of magway winding and inductive pick-up coil for experimentation.
2. Verify mutual inductance calculations by measurement.
3. Energize the magway winding and make power transfer measurements to the pick-up coil.
4. Make temperature rise and cooling measurements of the pick-up coil under electrically loaded conditions.
5. Measure AC and DC losses in the winding.
6. Interface with vehicle design for both mechanical and electrical compatibility.
7. Specify and build on-board pick-up coil for phase 3 vehicle.

TASK 71: ON-BOARD POWER SYSTEM DESIGN AND FABRICATION.

Objective: Develop on-board power system.

Risk: Low

Specific Tasks:

1. Integrate on-board power pick-up coil and battery as source for on-board power.
2. Design on-board power converter and bus structure.
3. Design on-board power distribution system.
4. Perform safety study of on-board electrical system.
5. Procure and fabricate components for on-board power system.

TASK 72: ON-BOARD SYSTEMS DESIGN

Objective: Develop vehicle systems for phase 3 testing.

Risk: Low

Specific Tasks:

1. Design./fabricate. landing gear skids and emergency brakes.
2. Design./fabricate mounts for magnet bogies and cooling system.
3. Integrate on-board power distribution system. Design and fabricate wire harnesses, power panels, compressors, hydraulic pumps, etc.
4. Design/fabricate mounts and power supplies for communications and controls.
5. Design/fabricate aero-control surfaces and actuators.
6. Design/fabricate environmental and access provisions.
7. Design/fabricate on-board signals and sensors.
8. Perform safety analysis of on-board systems.

TASK 73: VEHICLE FUSELAGE DEVELOPMENT

Objective: Construct phase 3 test vehicle.

Risk: Medium

Specific Tasks:

1. Develop and fabricate fuselage.
2. Assemble and test on-board systems.

TASK 74: VERIFY VEHICLE STRUCTURE

Objective: Verify structural properties of vehicle fuselage.

Risk: Low

Specific Tasks:

1. Fabricate and test sample fuselage material articles to demonstrate materials allowables, materials environmental properties and adhesive allowable.

2. Fabricate test samples to demonstrate fatigue strength, damage tolerance and impact strength. Measure flaw propagation characteristics.

3. Test lightening strike resistance.

4. Test corrosion resistance.

5. Test structures subcomponents including cabin skin, frames, stringers, magnet mounts, skid mounts, bulkheads, window attachments, shear webs, seat rails, fuselage section and firewall.

6. Test loaded fuselage. Static test.

TASK 75: ASSEMBLE FULL CAPABILITY VEHICLE

Objective: Assemble phase 3 test vehicle.

Risk: Medium

Specific Tasks:

1. Install on-board systems and test completed vehicle.

TASK 78: DYNAMIC POWER SYSTEM MODELING

Objective: Analyze series capacitor compensation circuit for various operating conditions. Identify suitable choices for active power system components.

Risk: Medium

Specific Tasks:

1. Outline an appropriate dynamic model for power system.

2. Identify the parameters and parametric ranges for the simulation. These will include grade, acceleration profile and component tolerances.

3. Design the simulation and perform validation tests.

4. Perform the simulation tests and identify the requirements for power system switching and other component requirements.

5. Contact major power component vendors.

TASK 79: MECHANICAL AND THERMAL LSM STUDY

Objective: Verify mechanical and thermal LSM properties.

Risk: High

Specific Tasks:

1. Perform a detailed thermal, electrical and mechanical design spec. (see task 80).

2. Construct test segment of winding.

3. Perform laboratory testing temperature rise of winding, dielectric breakdown, magnetic field pattern and inductance.

TASK 80: ADVANCED LSM AND POWER CONVERSION DESIGN

Objective: Design and develop advanced LSM construction methods. Develop specifications for advanced power conversion controls and capability including the ability to transmit power for the on-board vehicle power pick-up.

Risk: Medium

Specific Tasks:

1. Study performance of LSM and power conversion during phases 1 and 2 of the test program.
2. Identify and develop advanced LSM fabrication and installation techniques.
3. Identify vendors for LSM fabrication and estimate cost and delivery.
4. Identify new potential power circuit configurations.
5. Perform detailed circuit analysis to identify the size and type of components.
6. Estimate costs and potential reliability problems of each approach.
7. Select best power circuit.
8. Consider design parameters which may be changed, such as the power system and the auxiliary power frequency.

TASK 81: ADVANCED LSM AND POWER CONVERSION EQ. FABRICATION AND INSTALLATION

Objective: Procure and install necessary magway electrification equipment for phase 3 testing.

Risk: Low

Specific Tasks:

1. Identify vendors and installers of equipment.
2. Contract and manage procurement and installation.

TASK 84: LEVITATION PLATE THERMAL MODEL

Objective: Model the detailed thermal properties of the levitation plate box beam.

Risk: Medium

Specific Tasks:

1. Construct a detailed thermal model including the aluminum levitation plate box beam including the effect of conduction into the supporting structure. Model would be implemented on the SINDA software platform.

2. Compare the temperature rise and equilibrium temperature for different vehicle spacings and attachment methods.

3. Analyze thermal stresses and deflections for the above.

Note: Box beam thermal modeling will be an ongoing project from the inception of the program. In fact we have already done preliminary modeling using ANSYS, ref. Supplement C, FR. The description of this job in phase 3 indicates an intention to formally review all of the design at this point in the program to develop final design specs.

TASK 85: BOX BEAM CONSTRUCTION METHODS

Objective:

Develop cost effective, efficient approach to the fabrication of the levitation box beams.

Risk: Medium

Specific Tasks:

1. Verify all loading conditions, particularly the footprint from the coils and landing gear.

2. Verify allowable deflection and natural frequency criteria.

3. Obtain input from industry experts and investigate various methods of fabrication.

4. Select the most cost effective fabrication approach that meets schedule constraints.

5. Verify by analysis that the final box beam configuration will meet all criteria.

Note: Box beam design methods will be an ongoing project from the inception of the program. The description of this job in phase 3 indicates an intention to formally review all of the design and operational experience at this point in the program to develop final design specs.

TASK 86: FULL CAPABILITY TEST TRACK

Objective:

Design and construct the full capability test track including curves and a switch.

Risk: Medium

Specific Tasks:

1. Verify all design loadings on the magway.

2. Observe performance of the phase 1 and phase 2 magways and incorporate improvements as appropriate.

3. Determine curve geometry including the spirals.

4. Design additional site work as required, i.e. grading, drainage, access roads, fencing, etc.

5. Verify LSM width.

6. Design aluminum box beams incorporating information obtained from task 85.

7. Design support structure and footings.

8. Verify that magway design is "optimum" - adjust box beam length as required and redesign the system.

9. Construct foundations and vertical supports.

10. Fabricate, deliver and install box beams.

11. Align the magway.

5.3.10. SAFETY PLAN

CONTENTS

FIGURES

5.3.10.1. OVERALL APPROACH

This section of the concept definition report addresses safety and safety planning for the Magneplane system. It is divided into two parts which describe: (1) the overall approach to safety and (2) safety analyses conducted during the course of this contract.

Section 5.3.10.1. describes the general approach to safety and outlines those tasks which will be carried out throughout the design, construction, and operation phases of the Magneplane system. Numerical goals for safety-related failures and safety criteria are covered. Some specific philosophies and functions of the safety organization have been adapted from MIL-STD-882.

Section 5.3.10.2. discusses two types of safety analyses that have been conducted for the present design. The first of these is a summary of the safety-related responses to many system level issues such as weather, braking, obstacles, and control system failures. The second part covers preliminary hazard analyses. These analyses are essentially failure modes and effects analysis conducted at the concept level for all major subsystems to assure that the safety criteria can be met at later stages of design.

5.3.10.1.1. INTRODUCTION

Four hazard categories are defined for the system and are listed in Figure 1. The categories are defined in terms of the severity of damage to a single vehicle or passengers on a vehicle.

Theoretical numerical hazard rate goals were identified as targets for the design and operation of the system. Preliminary values are also shown in Figure 1 and are expressed as a probability of a mishap occurring per hour of vehicle operation. This basis is related to the underlying philosophy selected by Magneplane, that a rider should be exposed to a controlled minimum level of risk when using the system.

Four maintenance classifications are defined and listed in Figure 2. They range from Critical to Nonessential items. The table shows the priorities for servicing and maintaining the Magneplane system.

The criteria used to develop the safety assurance plan are as follows:

1. No single point failure shall result in a Category I or Category II hazard.

2. Any single point failure that results in a Category III or IV hazard shall be backed up by a safe mode that permits operation.

System safety design requirements will be specified after review of pertinent standards, specifications, regulations, design handbooks, and other sources of design guidance for applicability to the design of the system. Applicable standards from the following organizations will be included as a minimum:

Magneplane System Concept Definition Study

Hazard Category	Vehicle Damage	Personal Injury	Basis	Rate Goal	Terminology
I Catastrophic	Complete Loss 100%	Loss of Life	0.01 occurrences in 50 year life	1.52×10^{-9}	Extremely Improbable
II Severe	Severe 50%	Severe Injuries	1 occurrence in 50 year life	1.52×10^{-7}	Improbable
III Major	Major 25%	Major Injuries	1 occurrence every 5 years	1.52×10^{-6}	Remotely Possible
IV Minor	Minor 5%	Minor Injuries	1 occurrence every year	7.61×10^{-6}	Possible

Hazard Rate Goals are expressed as the probability of an occurrence in 1 vehicle-hour

Figure 1 Proposed theoretical hazard rate goals

Class	Description	*Response*
A	Critical	Equipment must be repaired immediately.
B	Serious	Equipment usable, but must be repaired as soon as possible.
C	Minor	Equipment stays in service. Repaired at end of day.
D	Nonessential	Equipment stays in service. Repaired at convenience.

Figure 2 Maintenance classifications

FRA: Federal Railway Administration

FAA: Federal Aviation Administration

NEC: National Electrical Code

NESC: National Electrical Safety Code

NFPA: National Fire Protection Association

OSHA: Occupational Safety and Health Act

ADA: American Disabilities Act

MIL-STD-882: Military Standard - System Safety Program Requirements

5.3.10.1.2. MIL-STD-882 - PHILOSOPHY

The safety system philosophy and some specific tasks have been adapted from Military Standard MIL-STD-882.

5.3.10.1.2.1. PURPOSE

This standard provides requirements for developing and implementing a system safety program to identify the hazards of a system and to impose design requirements and management controls to eliminate hazards or reduce risk to an acceptable level. It applies to all activities of the system life cycle; e.g., research, design, technology development, test and evaluation, production, construction, operation and support, modification and disposal.

5.3.10.1.2.2. SYSTEM SAFETY PROGRAM OBJECTIVES

The purpose of the system safety program is to define activities of system safety management and engineering required to identify, evaluate, and eliminate hazards throughout the system life cycle.

Some objectives of the system safety program are to assure that:

1. Safety consistent with mission requirements is designed into the system in a timely, cost-effective manner.

2. Hazards associated with each system are identified, evaluated, and eliminated, or the associated risk reduced to an acceptable level throughout the life cycle of the system.

3. Historical safety data, including lessons learned from other systems, are considered and used.

4. Minimum risk is sought in accepting and using new designs, materials, and production and test techniques.

5. Actions taken to eliminate hazards or reduce risk to a level acceptable are documented.

6. Retrofit actions required to improve safety are minimized through the timely inclusion of safety features during research, development, and acquisition of the system.

7. Changes in design, configuration, or mission requirements are accomplished in a manner that maintains an acceptable risk level.

5.3.10.1.2.3. SYSTEM SAFETY DESIGN REQUIREMENTS

Some general system safety design requirements that are being used in the design of the system are as follows:

1. Eliminate identified hazards or reduce associated risk through design, including material selection or substitution. When potentially hazardous materials must be used, select those with least risk throughout the life cycle of the system.

2. Locate equipment so that access during operations, servicing, maintenance, repair, or adjustment minimizes personnel exposure to hazards.

3. Minimize risk resulting form excessive environmental conditions.

4. Design to minimize risk created by human error in the operation and support of the system.

5. Consider alternate approaches to minimize risk from hazards that cannot be eliminated. Such approaches include interlocks, redundancy, failsafe design, system protection, fire suppression, and protective clothing, equipment, devices, procedures, and warnings.

6. Protect the power sources, controls, and critical components of redundant subsystems by physical separation or shielding.

7. Minimize the severity of personnel injury or damage to equipment in the event of a mishap.

8. Design software controlled or monitored functions to minimize initiation of hazardous events or mishaps.

9. Review design criteria for inadequate or overly restrictive requirements regarding safety.

5.3.10.1.2.4. SYSTEM SAFETY PRECEDENCE

The order of precedence for satisfying system safety requirements and resolving identified hazards is as follows:

1. Design for Minimum Risk. From the first, design to eliminate hazards. If an identified hazard cannot be eliminated, reduce the associated risk to an acceptable level.

2. Incorporate Safety Devices. If identified hazards cannot be eliminated or their associated risk adequately reduced, then reduce their risk to an acceptable level through the use of fixed, automatic, or other protective safety design features or devices.

3. Provide Warning Devices. Use warning devices to detect hazardous conditions and to produce an adequate warning signal to alert personnel. Warning signals and their application shall be designed to minimize the probability of incorrect personnel reaction.

4. Develop Procedures and Training. Where it is impractical to eliminate the hazards by use of the above methods, procedures and training may be used. Procedures and training or other forms of written advisory shall not be used as the only risk reduction method for Category I or II hazards.

5.3.10.1.2.5. RISK ASSESSMENT

Decisions regarding the elimination or reduction of hazards will be based on the risk involved. The hazard categories defined in Figure 1 are used in the assessment of risk to aid in achieving the safety objectives.

5.3.10.1.3. MIL-STD-882 - TASK DESCRIPTIONS

This section identifies several tasks adapted from MIL-STD-882.

5.3.10.1.3.1. PRELIMINARY HAZARD ANALYSIS

Purpose. The purpose of a preliminary hazard analysis (PHA) is to identify safety critical areas, evaluate hazards, and identify the safety design criteria to be used.

Task Description. A preliminary hazard analysis will be performed to obtain an initial risk assessment of a concept or system. The PHA effort will be started during the concept definition phase of the program so that safety considerations are included in tradeoff studies and design alternatives. Hazards associated with the proposed design or function will be evaluated for hazard severity, hazard probability, and operational constraint. Safety provisions and alternatives needed to eliminate hazards or reduce their associated risk to an acceptable level will be considered. The PHA shall consider the following for identification and evaluation of hazards as a minimum:

1. Hazardous components.
2. Safety related interface considerations among various elements of the system.
3. Environmental constraints including the operating environments.
4. Operating, test, maintenance, and emergency procedures.
5. Safety related equipment, safeguards, and possible alternate approaches.

5.3.10.1.3.2. SYSTEM SAFETY MANAGEMENT

Magneplane will establish a safety office to provide authority and administration of safety related programs.

The administrative responsibilities of the safety office will include:

1. Safety task planning
2. Establishing authority to implement safety tasks
3. Providing for staffing and funding

Technical responsibilities include:

1. Describing general engineering requirements and design criteria for safety.
2. Describing the risk assessment procedures.
3. Describing closed-loop procedures for taking action to resolve identified hazards.

The safety office will also be responsible for overseeing all safety tasks described in this plan.

5.3.10.1.3.3. SYSTEM SAFETY PROGRAM REVIEWS

Purpose. The purpose of this task is to establish a requirement to present system safety program reviews, to periodically report the status of the system safety program, and, when needed, to support special requirements such as certifications and pre-operational reviews.

Task Description. The safety office will provide system safety program reviews to periodically report the status of hazard analyses, safety assessments, and other parts of the system safety program. The safety office will support presentations to Government certifying activities and special reviews such as pre-operational reviews or pre-construction briefings.

The following details will be specified by the safety office to implement this task:

1. Identification of reviews, their content, and location.
2. Method of documenting the results of system safety reviews.
3. Schedule for system safety reviews.
4. Delivery schedule for any data required prior to and after the reviews.

5.3.10.1.3.4. HAZARD TRACKING AND RISK RESOLUTION

Purpose. The purpose of this task is to establish a closed-loop hazard tracking system. It assures that identified hazards are recorded, analyzed, and eliminated by corrective action.

Task Description. The safety office will develop a method or procedure to document and track hazards from identification until the hazard is eliminated or the associated risk is reduced to an acceptable level. This will provide an audit trail of hazard resolutions. A centralized file or document called a "hazard log" will be maintained. The hazard log will contain as a minimum:

1. A description of each hazard.
2. The status of each hazard.
3. The history of resolution action on each hazard from the time it was identified to the time the associated risk was reduced to an acceptable level.

The following details will be specified by the safety office to implement this task:

1. Hazard threshold for inclusion in the hazard log.
2. Content and format of the hazard log.
3. Procedure by which hazards are entered into the log.
4. Procedure to obtain close-out or risk acceptance.

5.3.10.1.3.5. TRAINING

Purpose. The purpose of this task is to provide training for personnel who will be involved with safety related activities such as hazard recognition, causes, effects, preventive and control measures, procedures, checklists, human error, safeguards, safety devices, protective equipment, monitoring and warning devices, and contingency procedures.

Safety Training of Operating Personnel. The safety office will conduct a system safety training program for certification of test, operating and support personnel. Approved safety procedures will be included in instruction lesson plans for the training program. Periodic refresher programs will be required.

Safety Training of Design Personnel. The safety office will develop safety training programs using results of system and operating hazard analyses. The training programs will provide for specific levels of personnel including: managers, engineers, and technicians involved in the design of safety critical equipment. Periodic refresher programs will be required.

General Training Requirements. The safety office will review the training programs for all operating personnel. The programs will be reviewed to verify that appropriate instruction is provided for all safety-related operations or potentially safety-related activities. Periodic refresher programs will be required.

5.3.10.1.3.6. SAFETY COMPLIANCE ASSESSMENT

Purpose. The purpose of this task is to perform and document a safety compliance assessment to verify compliance with federal, national, and industry codes imposed contractually or by law to ensure safe design of the system. The assessments will also comprehensively evaluate the safety risk being assumed prior to test or operation of the system or at contract completion.

Task Description. The safety office will perform and document a safety compliance assessment to identify and document compliance with appropriate design and operational safety requirements. The assessment identifies the contractually imposed standards, specifications, and codes appropriate to the safety of the system and documents compliance with these requirements. The assessment includes necessary hazard analysis, design drawing and procedural reviews, and equipment inspections.

A safety compliance assessment will:

1. Identify contractual federal, national, and industry safety specifications, standards, and codes applicable to the system and document compliance with these requirements.

2. Identify and evaluate residual hazards inherent in the system or that arise from system-unique interfaces, installation, test, operation, maintenance, or support.

3. Identify necessary specialized safety design features, devices, procedures, skills, training, facilities, support requirements, and personnel protective equipment.

4. Identify hazardous materials and the precautions and procedures necessary for safe storage, handling, transport, use, and disposal of the material.

5.3.10.1.3.7. SOFTWARE REQUIREMENTS HAZARD ANALYSIS

Purpose. The purpose of this task is to perform and document a software requirements hazard analysis. The safety office will examine system and software requirements and design in order to identify unsafe modes for resolution, such as out-of-sequence, wrong event, inappropriate magnitude, inadvertent command, adverse environment, deadlocking, failure-to-command modes, etc.

The software requirements hazard analysis uses the preliminary hazard analysis as its input. The analysis shall examine the safety-critical computer software components at a gross level to obtain an initial safety evaluation of the software system. The output of this review is used as input to other safety analyses.

Review Software Specifications. The safety office will review software specifications and identify hazards related to any of the specifications or documents.

The safety office will assure that the System Safety Requirements are correctly and completely specified, that they have been properly translated in to software requirements, and that the software safety requirements will appropriately influence the software design and the development of the operator, user, and diagnostic manuals. To do this the contractor shall review, as a minimum, the following documents:

1. Subsystem Specifications.
2. Software Specifications.
3. Interface Requirements Specifications and other interface documents.
4. Functional Flow Diagrams and related data.
5. Storage allocation and program structure documents.
6. Background information relating to the contemplated testing, manufacturing, storage, repair, use, and final disposition.
7. Information concerning system energy, toxic and other hazardous event sources, especially ones which may be controlled by software.
8. Software Development Plan, Software Quality evaluation Plan, and Software Configuration Management Plan.

Develop Design and Testing Requirements. The safety office will develop safety related design and testing requirements to be incorporated into the software test plans. The following steps will also be carried out:

1. Develop safety-related change recommendations to the specification documents listed above, including means of verification.
2. Develop safety related design requirements for incorporation into hardware and software requirements.
3. Develop safety related test plans, test descriptions, test procedures, and test case requirements for incorporation into the appropriate subsystem test documents.

5.3.10.2. CURRENT EFFORTS

This section covers two types of safety analyses that have been conducted for the present design. The first of these is a summary of the safety-related responses to many system level issues such as weather, braking, obstacles and control system failures. The second part covers preliminary hazard analyses.

5.3.10.2.1. SYSTEM-LEVEL RESPONSES

5.3.10.2.1.a. WAYSIDE CONTROL OR COMMUNICATION FAILURE

Vehicles affected will immediately deploy emergency brakes and come to a full stop. Safe headway policy assures that there is adequate stopping distance ahead of the affected vehicle. Global control will prevent other vehicles from entering affected blocks.

5.3.10.2.1.b. GLOBAL CONTROL OR COMMUNICATION FAILURE

The functions of a failed global control center can be assumed by neighboring global control centers. In the event of total global control failure, a portable workstation can be connected to a wayside controller, and the system can be operated from that point.

5.3.10.2.1.c. MAGWAY INTEGRITY

Continuous ride quality monitoring from the vehicles will detect magway problems. Magway discontinuity detectors will also be used to indicate large structural discrepancies. Global control will safely stop affected vehicles in the event of a problem.

5.3.10.2.1.d. MAGWAY OBSTACLES

Stopped vehicle in magway. Global control will know the position of the stopped vehicle, and will stop the next vehicle within a safe distance using the primary braking system (LSM). Vehicles further back can be slowed gradually.

Foreign objects in magway. The design of the system will minimize the risk of damage from foreign objects by the use of elevated magways, fences in selected areas, and a wide gap between the vehicle and the magway.

To detect large objects in the magway, operators will patrol the magway at reduced speed each morning. The entire system can be quickly covered by using one vehicle from each magport to patrol to the next magport. In addition, magway monitoring may be used in selected areas.

If a vehicle does hit an object, on-board accelerometers or the operator will indicate poor ride quality and will alert the system to a possible problem.

5.3.10.2.1.e. WEATHER

Global control will be connected to weather and disaster networks. Global control operators will have advanced information on adverse weather and will react appropriately.

Snow or ice. Normal operation of the system generates enough heat in the levitation sheets to melt a substantial amount of snow and ice. The system will be operated at reduced speed to provide adequate emergency brake performance.

High winds, hurricanes, tornados. The magway will shelter the vehicle from some of the effects of crosswinds. The vehicles will be adversely affected only by extremely high winds. If the winds are too high, global control will slow the vehicles and keep them in the magports.

Thunderstorms. The vehicles, like airplanes, will be able to withstand moderate lightning strikes. If there is heavy thunderstorm activity, vehicles may be slowed or detained in the magports. The magway will be continuously grounded, and will able to withstand a lightning strike.

Rain and fog. Rain and fog will not affect vehicle performance. The system may be operated at reduced speed to provide adequate emergency brake performance.

5.3.10.2.1.f. EARTHQUAKE

Global control will be connected to local earthquake networks, if available in the seismic zone of the system. Vehicles may be slowed in the vicinity of an earthquake, if it were judged strong enough to cause structural damage to the magway. The magway will be patrolled for structural integrity by the passing vehicles. After the magway has been patrolled and judged safe, the vehicles may proceed at full velocity.

5.3.10.2.2. PRELIMINARY HAZARD ANALYSES

5.3.10.2.2.1. AERODYNAMIC CONTROLS

5.3.10.2.2.1.a. SUBSYSTEM DESCRIPTION

A simplified block diagram of the vehicle's aerodynamic controls appears in Figure 3.

Each aerodynamic control surface is operated by an electromechanical actuator. The actuators (and their associated power electronics) receive control signals from the vehicle stability control system. Power is supplied by the vehicle power system.

The aerodynamic control surfaces are organized as follows:

Forward Group

1. (2) Horizontal Surfaces

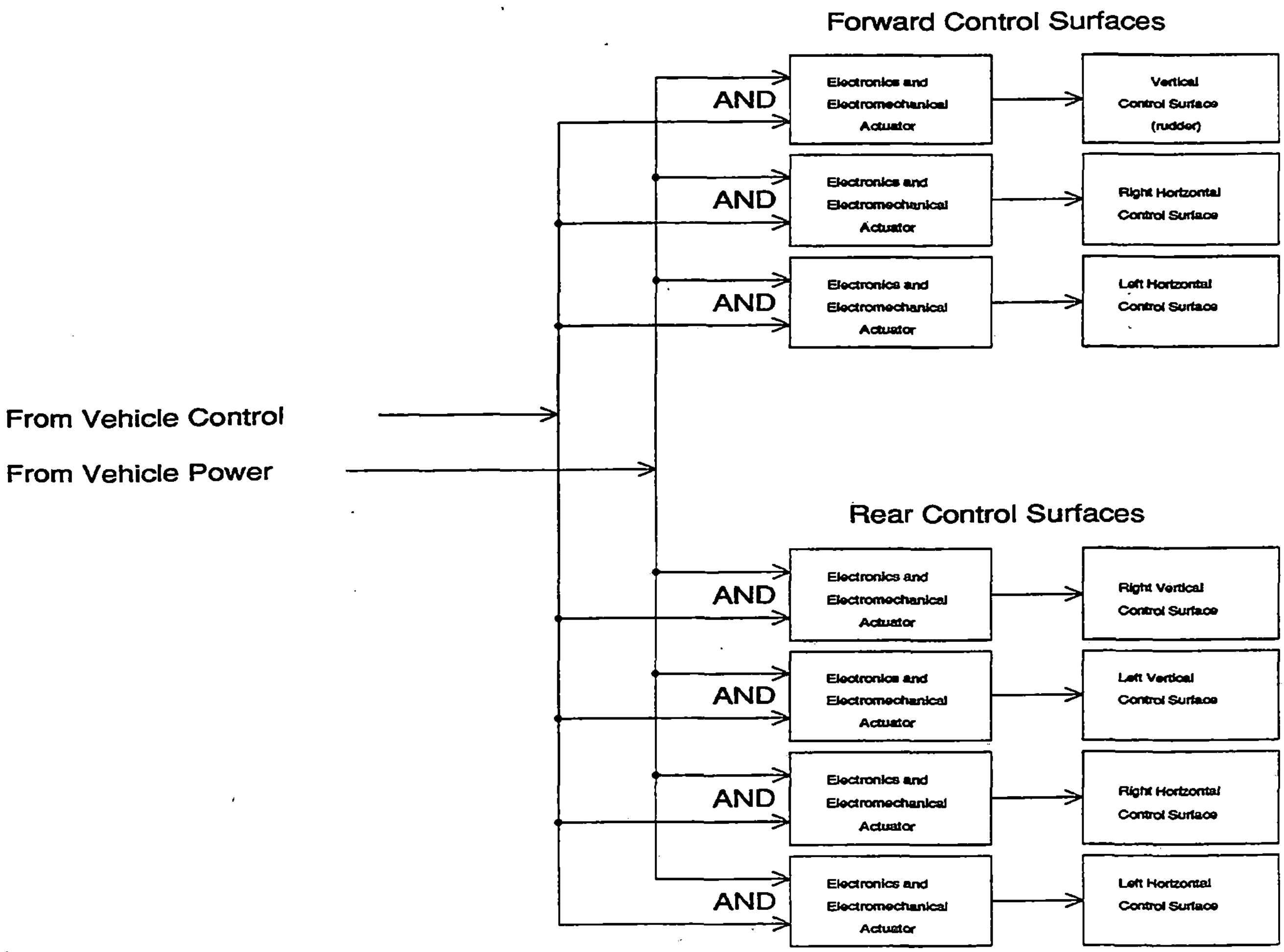


Figure 3 Simplified block diagram of the aerodynamic controls

2. (1) Vertical Surface

Rear Group

1. (2) Horizontal Surfaces
2. (2) Vertical Surfaces

5.3.10.2.2.1.b. PRELIMINARY HAZARD ANALYSIS

1. Mechanical Failure of An Actuator

A single control surface remains in its last position. Vehicle stability control is degraded and ride quality is reduced. The severity depends on which surface is affected. Class B maintenance is required.

2. Loss of Vehicle Power

All control surfaces fail to operate. Ride quality is seriously degraded. This is a potential Category IV hazard. Since vehicle power is composed of independent left and right side systems, one arrangement under consideration is to provide redundant power connections to the actuators. If this arrangement is used, the control surfaces still operate even if one power system fails. The vehicle is taken off-line and repaired but the passengers are completely unaffected.

3. Bird Strike

The control surfaces will be designed with bird strike resistance in mind. Since an individual bird strike event can only affect a limited number of surfaces, it is expected that only a degradation in ride quality will result.

4. Unexpected Operation or "Hardover"

In the worst case, this condition becomes similar to what is known the in aircraft trade as a "hardover." It is the effect of suddenly moving the control surfaces to their maximum extension in a coordinated fashion. For example, all surfaces creating roll in one direction.

This condition has been analyzed and can result in a Category III hazard at worst. In addition, it would require that most of the actuators be operational and receive a specific combination of incorrect command signals.

5.3.10.2.2.2. VEHICLE ATTITUDE CONTROL SYSTEM

5.3.10.2.2.2.a. SUBSYSTEM DESCRIPTION

The vehicle attitude control subsystem provides for smooth and precise movement of the vehicle in the magway. It controls six movements of the vehicle; thrust, pitch, heave, roll, sway, and yaw. The LSM provides thrust and a portion of the heave control forces. In that regard, the LSM and aerodynamic control work together to control vehicle attitude during flight.

The simplified block diagram in Figure 4 shows how the LSM and aerodynamic control work together. Vehicle sensors provide input signals to the flight controller for ride and attitude control. The flight controller then communicates to the wayside by RF transmitter/receivers, the needed thrust and heave commands. Simultaneously, it sends commands to the aerodynamic controls for coordinated corrections of the vehicle motion.

Blocks drawn with a "shadow" effect are redundant. Generally, these are dual redundant systems as in the case of the flight controller and RF transmitter/receiver pairs. Certain vehicle sensors may have higher levels of redundancy. More than dual redundancy is not required to meet safety requirements. This will be shown in the following discussion.

5.3.10.2.2.2.b. PRELIMINARY HAZARD ANALYSIS

1. Complete Failure of the Attitude Control Subsystem

This could only be caused by a failure of the redundant flight control system and the LSM, which could not be a result of a single-point failure.

2. Failure of Aerodynamic Control

Failure of the aerodynamic actuators could result in a partial failure of the aerodynamic control system. A complete failure is extremely improbable but would result only in severely degraded ride quality.

The failure is detected by the control system. The landing gear is deployed and the vehicle is operated at reduced speed using the LSM. This is a Class B maintenance condition.

3. Failure of LSM

The LSM becomes inoperative when the LSM winding itself fails, when the converter fails, or when there is a general loss of power.

Aerodynamic control dominates the LSM at high speed, so high speed failures are not serious. When the failure is detected, the vehicle speed is reduced due to the loss of propulsion.

LSM failures are treated in detail in Section 5.3.10.2.2.10.

5.3.10.2.2.3. VEHICLE ELECTRICAL SYSTEM

5.3.10.2.2.3.a. SUBSYSTEM DESCRIPTION

A simplified block diagram of the vehicle electrical system is shown in Figure 5. On-board power is configured as a dual system for safety and redundancy. Each side (usually denoted as left and right side circuits) has a separate power source. AC power is converted to 270 Vdc and supplies a battery charging circuit. The 270 V bus also supplies dc/ac converters which provide ac power for major vehicle loads.

5.3.10.2.2.3.b. PRELIMINARY HAZARD ANALYSIS

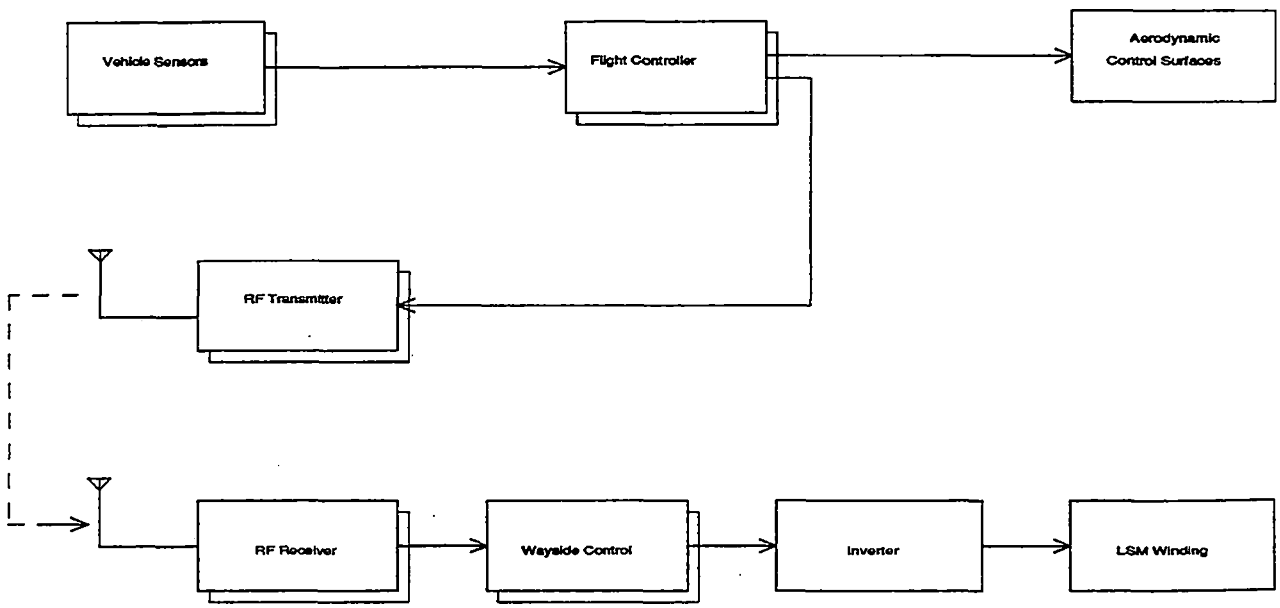


Figure 4 Simplified block diagram of attitude control system

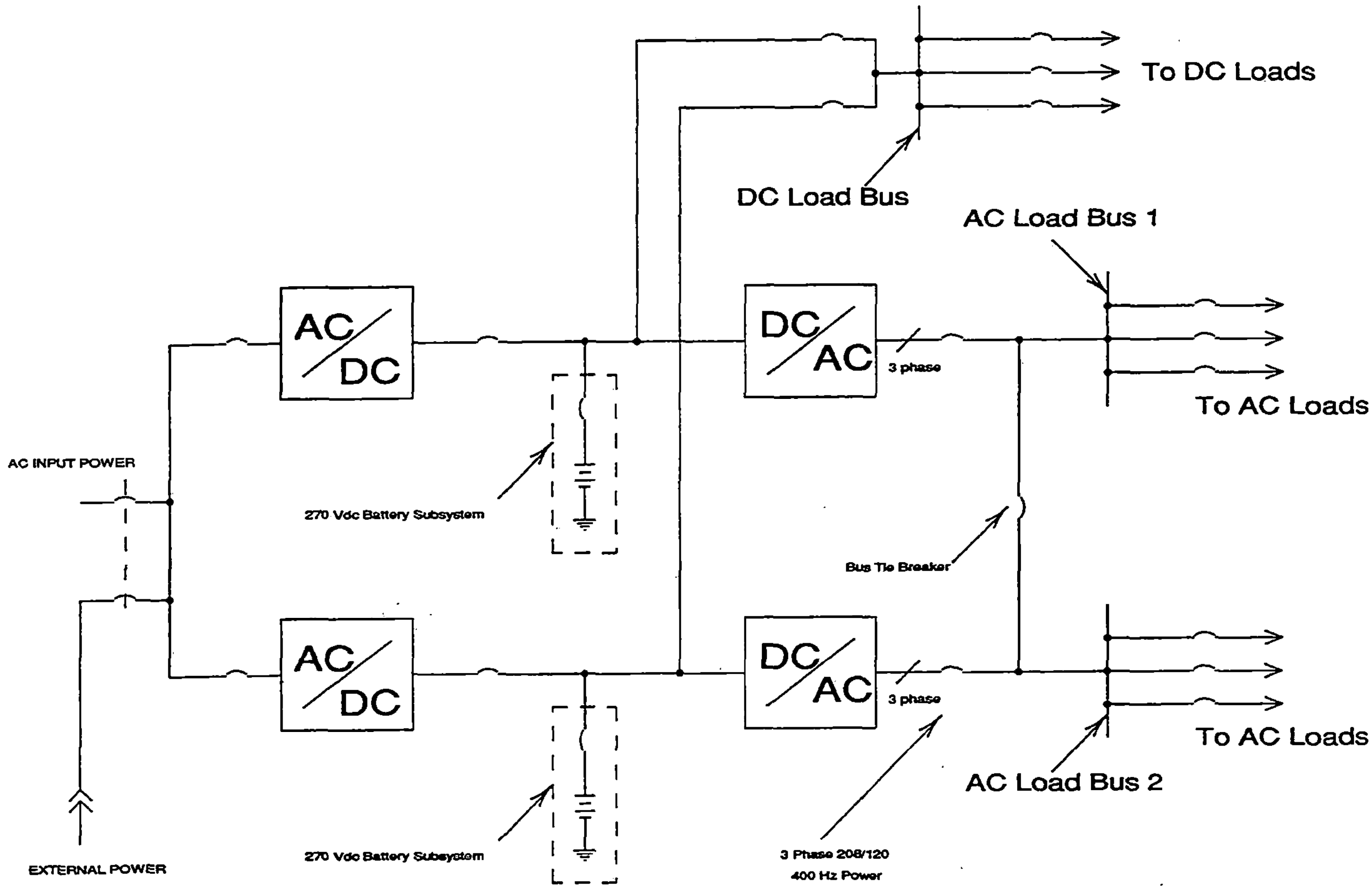


Figure 5 Simplified block diagram of the vehicle electrical system

1. Electrical Overloads

Circuit breakers on all major load circuits prevent short circuits on load devices from causing prolonged overcurrent conditions. This prevents conductor overheating, a primary cause of electrical fires.

2. Battery Failure

Each battery string is protected from overcurrent conditions due to shorts and individual battery failures by a circuit breaker. Individual fuses could be used to prevent short circuits from mid-string connections.

Complete mechanical failure of a battery or string of batteries could result in dispersion of caustic materials in the lower fuselage. Batteries will be maintained in insulated plastic trays to prevent these materials from coming in contact with the structure of the vehicle. A separate ventilation compartment will be used to prevent fumes from entering the passenger compartment ventilating system. A battery failure would reduce vehicle backup power and is viewed as a Class C maintenance item.

3. Converter Failures

The ac/dc and dc/ac power converters will be self-protected against abnormal input or output conditions. In addition, no unsafe conditions can result from internal component failures.

5.3.10.2.2.4. SUPERCONDUCTING MAGNETS AND CRYOGENIC REFRIGERATION

5.3.10.2.2.4.a. SUBSYSTEM DESCRIPTION

This system operates by supplying cryogenic helium through headers and piping to superconducting magnet cryostats. Figure 6 shows a simplified block diagram of the cryogenic refrigeration system and superconducting magnets. It consists of:

1. Propulsion magnets and cryostats

   There are twelve superconducting propulsion coils located in two modules of six coils each. Each module contains a single cryostat independently supplied by the refrigeration system. The six coils in a given module are cryogenically in parallel, electrically in series, and operated in the persistent mode.

2. Levitation magnets and cryostats

   There are eight superconducting levitation coils located in four modules of two coils each. Each module contains two cryostats so that the coils are independently supplied by the refrigeration system. The coils are electrically independent and operated in the persistent mode.

3. Cryogenic transfer lines
   The above propulsion and levitation modules are arranged in two bogies, one at the front of the vehicle and one at the rear. Each bogie is supplied with cryogenic helium by a

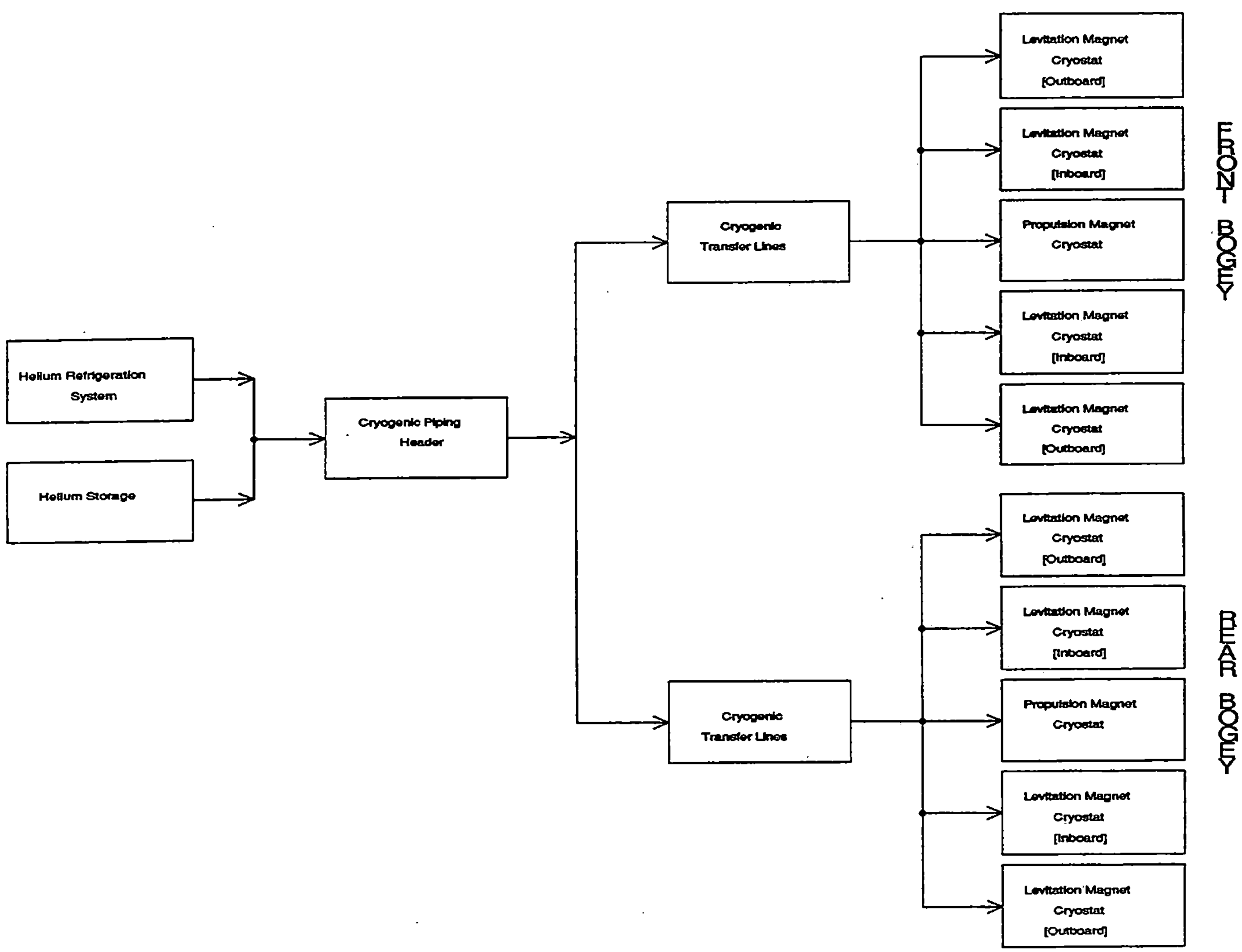


Figure 6 Simplified block diagram of the superconsucting magnets/cryogenic refrigeration system

separate cryogenic transfer line.

4. Distribution header cryostat

   There is one distribution header cryostat which supplies each transfer line with cryogenic helium.

5. Helium compressor and refrigeration

6. Cryogenic helium storage

5.3.10.2.2.4.b. PRELIMINARY HAZARD ANALYSIS

1. Propulsion magnet cryostat failure

Failure of a cryostat would cause the coil inside to quench as it warms above superconducting temperature. During the quenching process, the current in the superconducting coil would decay to zero. The quench of a single coil in a cryostat would naturally propagate into the other coils in the module. Alternatively, quenches in the other five coils could be actively triggered by a quench detection system which warms the coils locally.

The loss of vacuum in a cryostat would cause all the coils in that module to fail simultaneously. The remaining propulsion module would be unaffected and would provide enough thrust for the vehicle to reach the next magport at reduced speed. Class B maintenance would be required.

If both propulsion modules failed, the vehicle would have no propulsion and minimal guidance. The vehicle would slow to a stop and require Class A maintenance. The propulsion magnets are also part of the primary braking system. If necessary, the emergency braking system could be deployed.

2. Levitation magnet cryostat failure

As with the propulsion magnet cryostats, failure of a levitation cryostat would cause the coil inside to quench. The quench detection system would trigger a quench in the coil symmetrically located on the other side of the vehicle centerline. The coils adjacent to the quenching coils would remain superconducting, experience a current increase of 23% and provide sufficient lift to prevent vehicle contact with the magway. The operating clearance to the magway would decrease by 0.05 m, and the vehicle could operate at reduced speed. The remaining levitation modules on the other end of the vehicle would be unaffected and would provide lift at the usual clearance. Class B maintenance would be required.

The failure of all of the levitation cryostats would initiate a quench in all of the levitation magnets. These quenches may not be simultaneous. To assure a symmetric loss of levitation relative to the vehicle centerline, the quench detection system will actively trigger a quench in the coil symmetrically located on the other side of the vehicle. The time scale is such that the landing gear can be deployed quickly enough to avoid having the vehicle come in contact with the magway. The vehicle could continue travelling on the landing gear at reduced speed. Class B maintenance would be required.

3. Cryogenic transfer line failure

Failure of a transfer line would cut off flow of cryogenic helium to the associated magnet cryostats. The cryostats would be valved off and would have sufficient thermal capacity to remain in the superconducting state until the vehicle reaches the next magport. Class B maintenance would be required.

4. Distribution header cryostat failure

Failure of the distribution header cryostat would cut off flow of cryogenic helium to both transfer lines. The magnet cryostats would be valved off and would have sufficient thermal capacity to remain in the superconducting state until the vehicle reaches the next magport, as above. Class B maintenance would be required.

5. Compressor and refrigeration system failure

In the event of a compressor or refrigeration system failure, the system would automatically switch over to the cryogenic helium storage tank. This tank can supply 30 minutes of cryogenic helium. If this reserve were depleted, the magnet cryostats would be valved off as above. Class B maintenance would be required.

6. Cryogenic helium storage failure

Failure of the cryogenic helium storage tank would be detected by pressure and temperature sensors. Since this is a backup system this would not be considered a hazard, but would require Class C maintenance.

5.3.10.2.2.5. DOORS AND DOOR INTERLOCKS

Four doors are provided: one at each side, and at both the front and rear of the vehicle. The doors are sliding and move open and closed by compressed air.

5.3.10.2.2.5.a. PRELIMINARY HAZARD ANALYSIS

Standard safety features common to aircraft doors will be included in the design. Some of these are listed below:

1. Safeguarded against inadvertent opening
2. Can be opened from inside or outside
3. Electrically interlocked to vehicle control systems

5.3.10.2.2.6. SEATING, HANDRAILS AND STEPS

Standard aircraft-style seating will be used. Handrails, steps, and other hardware related to passenger motion will meet applicable safety standards.

5.3.10.2.2.7. LANDING GEAR AND EMERGENCY BRAKES

5.3.10.2.2.7.a. SUBSYSTEM DESCRIPTION

A simplified block diagram of the vehicle emergency braking and landing gear subsystems is shown in Figure 7. Both functions will be divided into fore and aft system; each will have its own hydraulic accumulator. There will be one hydraulic pump. The extension mechanism is a simple hydraulically extended strut.

5.3.10.2.2.7.b. EMERGENCY BRAKE OPERATION

A hydraulic accumulator is provided for rapid extension of the struts in emergency conditions. The accumulator is charged by an electrically powered hydraulic pump which pressurizes an air cushion in the accumulator. A normally opened solenoid valve connects the accumulator to the struts. The valve is held closed electrically. When it is opened, hydraulic fluid is forced into the struts by the pressurized air. The operating time in this mode is three to five seconds.

Pertinent safety features are as follows:

- A sensor is provided to assure that the vehicle is not dispatched unless the accumulator is pressurized.
- The hydraulic accumulator provides for emergency operation of the braking system even if a portion of the vehicle power system fails.
- The system is designed to operate automatically upon total loss of vehicle power. It is failsafe.

5.3.10.2.2.7.c. LANDING GEAR OPERATION

The landing gear struts are similar to those used for the emergency brakes. When the struts extend, anti-friction pads support the vehicle at low speeds, at a variety of heights, on either a flat or curved trough.

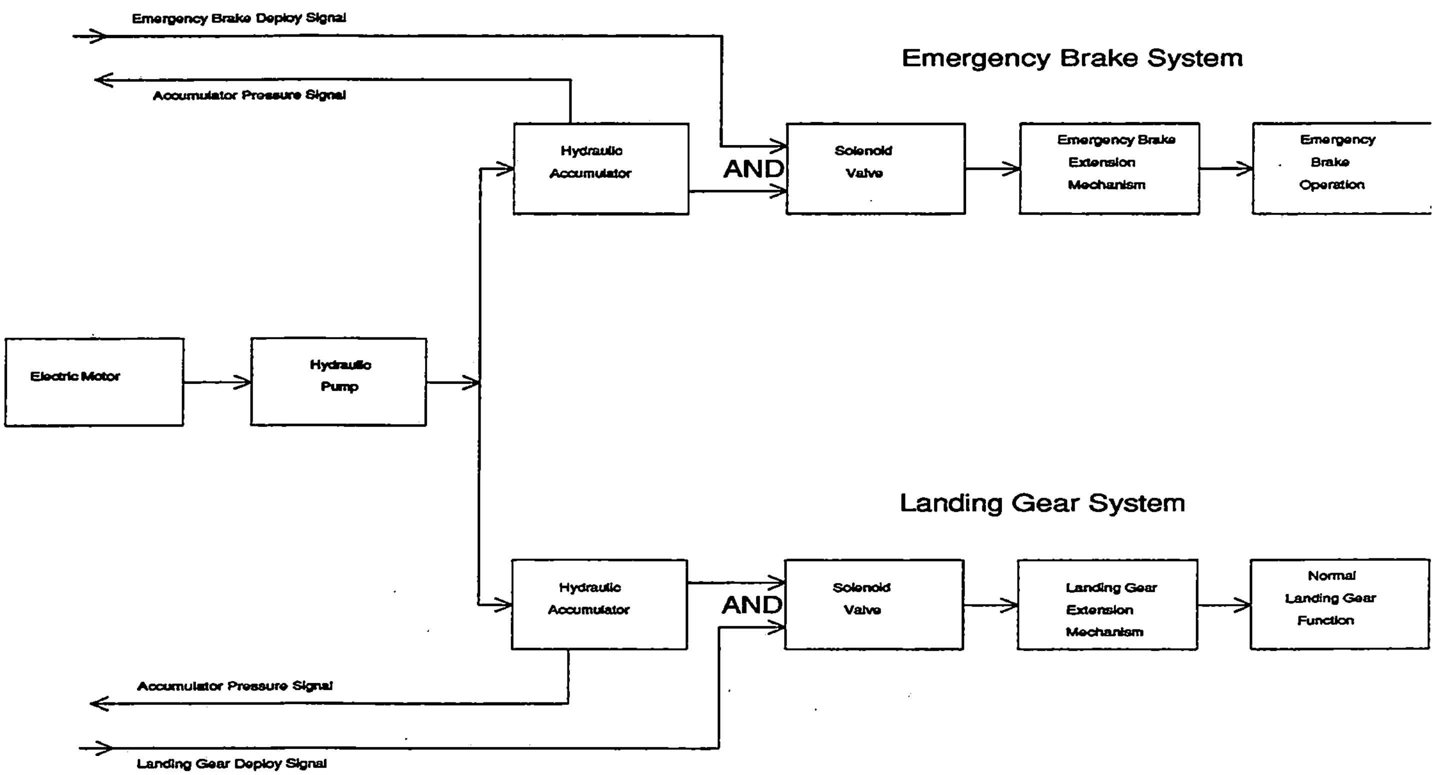
Operation and design are similar to the emergency brake with the following exceptions:

1. Operating time is longer: ten to fifteen seconds.
2. The four struts are coordinated for smooth operation.

5.3.10.2.2.7.d. PRELIMINARY HAZARD ANALYSIS

General Comments:

- The emergency braking and landing gear equipment will undergo a "pre-flight" check. Failures detected at this stage are not considered to be hazardous conditions.
- Each strut is independent. No single-point failure can result in a failure of the entire emergency braking or landing gear system.



Notes:

1. Emergency Deploy Signal is Failsafe : Deploys gear on total loss of vehicle power
2. Accumulator Pressure Signal is Failsafe : Loss of signal prevents vehicle dispatch
3. Landing Gear and Emergency Brakes are split into Fore and Aft Systems

Figure 7 Simplified block diagram of the landing gear and emergency brakes

1. Failure of One Extension Mechanism

The functions for the affected strut fail. The vehicle settles unevenly. The weight of the vehicle is distributed unevenly onto three sets of brake pads. Braking is largely unaffected since the vehicle weight is still supported on the high friction material.

Minor vehicle damage and personal injuries can result. This is a Category IV hazard.

2. Unexpected Deployment of One Extension Mechanism

Aerodynamic and LSM control compensate for the uneven operation of the vehicle. Normal braking with LSM begins and the remaining struts are extended. This is a Category IV hazard, Class B maintenance condition.

5.3.10.2.2.8. MAGNETIC FIELD SHIELDING

5.3.10.2.2.8.a. SUBSYSTEM DESCRIPTION

The shielding system is a set of conventional coils operating at relatively low power levels. The windings will be distributed in the floor and walls of the vehicle in the vicinity of each bogie. Coils will be operated in a series/parallel configuration that will assure that total shielding cannot be lost by loss of a single coil because of short circuit or accidental severing of a power lead through impact.

5.3.10.2.2.8.b. PRELIMINARY HAZARD ANALYSIS

1. Loss of Power

If total shielding is lost because of loss of on-board power, the passengers could be exposed to a higher than usual field level for a period of time. However, they would be exposed to: 1) less than 50 gauss in the loss-of-shield state if access is restricted to be greater than 0.7 m from the end plane of the bogie; 2) less than 5 gauss if access is restricted to be greater than 2.2 m of the end plane of the bogie; or 3) less than 1 gauss if access is restricted to be greater than 4.0 m of the end plane of the bogie.

Loss of shielding will be detected by on-board sensors so that passenger access can be restricted as described above.

2. Coil Failure

The failure of an individual coil cannot cause failure of the entire shielding system. The resulting field will be lower than that for a total power loss. This represents a Class C maintenance condition.

5.3.10.2.2.9. BOX BEAM/LEVITATION SHEETS

5.3.10.2.2.9.a. SUBSYSTEM DESCRIPTION

The levitation box beams, which are part of the magway trough, consist of a pair of three-celled box beams symmetric about the magway centerline. Each box beam is made up of a curved upper sheet of .02m thickness. The bottom plate also is a curved panel. The two curved panels are held together by four equally spaced longitudinal stiffeners.

The levitation sheet box beam design includes thermal expansion joints to accommodate expansion. The joint incorporates a 1 m long backing plate that straddles the joint region underneath. One beam is fixed at the concrete pier support while the other is supported by and allowed to slide over the backing plate.

5.3.10.2.2.9.b. PRELIMINARY HAZARD ANALYSIS

Single point failures in any one structural component of the box beam cannot lead to a catastrophic failure. Multiple fasteners, joints, and structural members bear the load.

The backing plate is a typical example of redundancy in the structural design. It is supported from below by four gussets, any three of which can support the load of the adjacent box beam.

In addition to the basic design of the box beam itself, several functions will be employed to detect progressive structural problems:

1. Continuous ride quality monitoring will detect ride disturbances which might result from abnormal beam alignment, deflection, or damage.

2. Box beam continuity detectors span the expansion joint and provide an electrical signal which provides a continuous indication of magway integrity.

5.3.10.2.2.10. LINEAR SYNCHRONOUS MOTOR WINDING

5.3.10.2.2.10.a. SUBSYSTEM DESCRIPTION

The Linear Synchronous Motor (LSM) winding is a three phase winding constructed of interconnected segments each 9 m long. Three phase power protection circuits provide for the following detectable electrical conditions at the output of the converter:

1. Ground fault

2. Unbalanced phase currents

3. Overcurrent

5.3.10.2.2.10.b. PRELIMINARY HAZARD ANALYSIS

LSM winding failures will always result in loss of propulsion and some guidance, which is a Category III hazard. Electrical protection circuits assure that overcurrent conditions are terminated quickly to prevent damage to the magway to equipment.

Vehicles affected will immediately deploy emergency brakes and come to a full stop. Safe headway policy assures that there is adequate stopping distance ahead of the affected vehicle. Global control will prevent other vehicles from entering affected blocks.

1. Short Circuit

Protected by overcurrent protective devices. A controlled shut down of the converter is always attempted simultaneously in the case of moderate overcurrent. The converter output circuit breaker is independent of controlled shutdown, which depends on the converter integrity.

2. Insulation Failure to Ground

Protected by ground fault protection circuits.

3. Insulation Failure Phase-to-Phase

Protected by detection of unbalanced phase currents. This is usually called phase imbalance. The condition may also be prevented by detecting the difference between the input and return currents for each phase of the winding, called differential current detection.

5.3.10.2.2.11. MAGSWITCH

5.3.10.2.2.11.a. SUBSYSTEM DESCRIPTION

The Magneplane passive magnetic switching concept is a complex electromagnetic structure. Fundamentally, vehicle guidance while in the switch is obtained from an interaction between the vehicle's propulsion coils and null flux coils in the magway. Each switch provides two paths: a straight-through path where the vehicle proceeds along its normal course, and a turnout where the vehicle makes a turn away from the straight magway. These two paths have independent sets of null flux coils and LSM windings.

Guidance to drive the vehicle along either path is generated when the vehicle passes over closed-circuited null flux coils. A power contactor is provided for each coil and controls the operation: opening the contactor disables the coil, closing the contactor causes that coil to be active.

The switch is failsafe by design. Null flux coils along the straight-through path are provided with contactors that are normally closed. In the event of a power failure, the vehicle will travel along the straight-through path. In addition, the contactors are provided with interlocks so that their position can be verified. Also, a number of coil failures can be tolerated without a major disturbance to the guidance forces for the vehicle since about 1000 individual coils are used in each path.

A simplified block diagram of the switch is shown in Figure 8. DC power for the contactor coils is provided by a power supply located in the nearest wayside converter station. A control signal from Global Control activates the power supply and energizes both sets of contactors. This opens the set of null flux coils for the straight-through path and closes the coil for the turnout path. Interlocking verifies the contactor positions prior to the vehicle entering the block containing the switch. Propulsion coils on the vehicle interact with the null flux coils and guide the vehicle along the turnout.

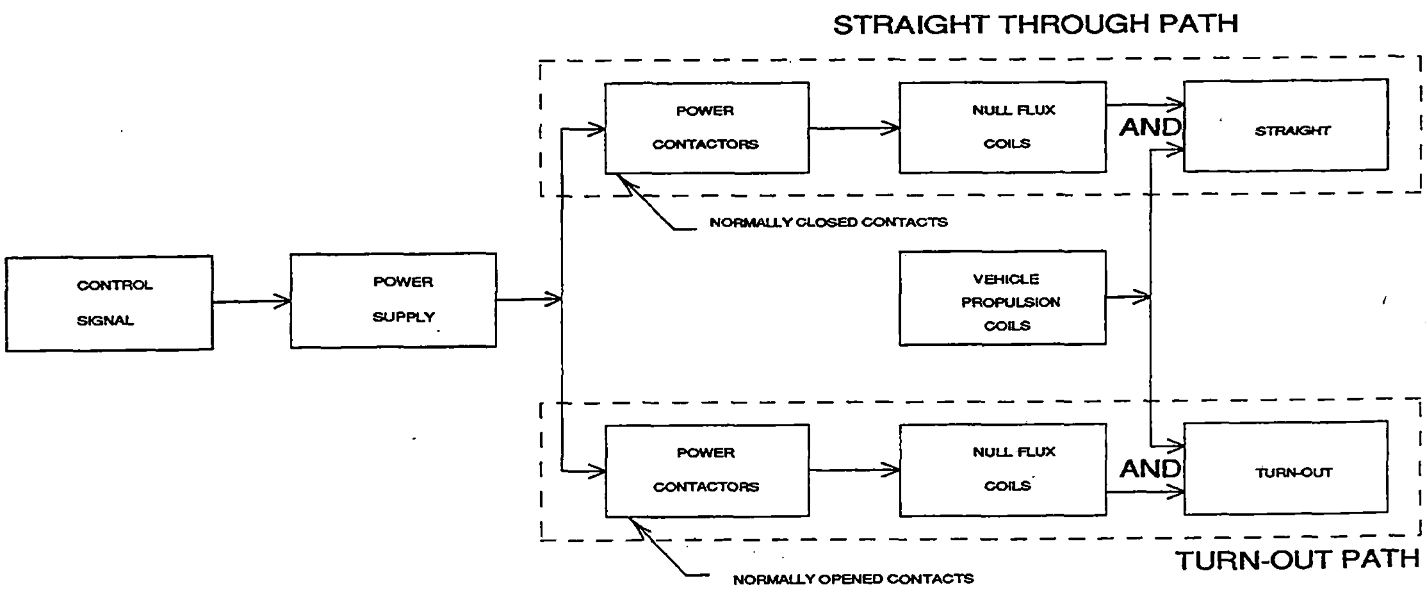


Figure 8 Simplified block diagram of the magswitch

5.3.10.2.2.11.b. PRELIMINARY HAZARD ANALYSIS

1. Loss of Control Signal

Loss of the control signal will generally deactivate the contactor power supply. This results in an erroneous switch condition. This can be verified by checking the state of the interlocks. Global Control will be aware that the switch is in the wrong position and take appropriate re-routing action. The vehicles will be notified ahead of time that they will be proceeding along the straight-through path.

2. Failure of Contactor Power Supply, or General Power Outage

In this case, the switch reverts to its straight-through condition which can be verified by interlocking signals.

3. Loss of Vehicle Propulsion Coils

The vehicle propulsion coils are needed for safe vehicle guidance in the switch. A sudden complete failure of all propulsion coils in both bogies would be required to cause a Category I hazard. Many of the intermediate failures, such as one coil quenching, can be detected before a dangerous loss of guidance occurs. The only way an undetected loss of all propulsion coils can occur is when the vehicle is subjected to sudden and severe impact damage. The failure of the switch to function under this condition does not constitute an independent hazard.

5.3.10.2.2.12. POWER SYSTEM

5.3.10.2.2.12.a. SUBSYSTEM DESCRIPTION

A block diagram of the Magneplane propulsion power system is shown in Figure 9. Dual 115 kv and 34.5 kv lines are used for redundancy.

5.3.10.2.2.12.b. PRELIMINARY HAZARD ANALYSIS

1. Single 115 kv or 34.5 kv Line Failure

No loss in power or disruption to system. This is a Class C maintenance condition. Loss of either 2-115 kv or 2-34.5 kv lines will cause loss of propulsion power to the affected area of the system.

2. Converter Failure

Propulsion power is lost on the affected block. A tie breaker may be used to connect an operating converter to the affected block to remove stranded vehicles.

5.3.10.2.2.13. GLOBAL AND WAYSIDE CONTROL AND COMMUNICATION

5.3.10.2.2.13.a. SUBSYSTEM DESCRIPTION

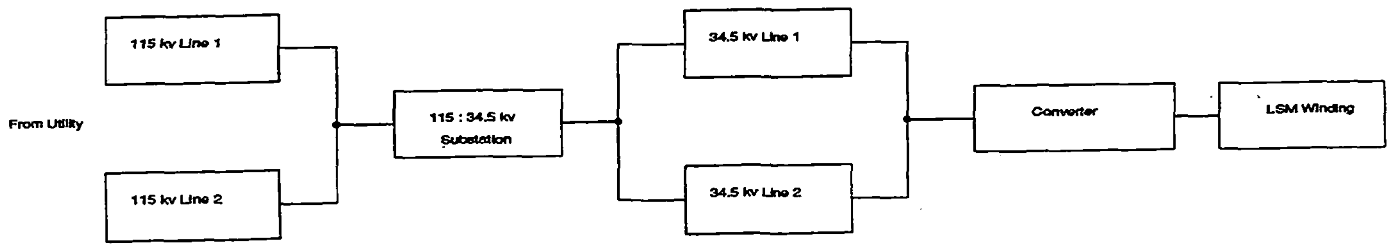


Figure 9 Simplified block diagram of the power system

The Global control centers (GCC) each control approximately 160 km of the Maglev system via communication with wayside controllers. Figure 10 shows a simplified block diagram. Each GCC is connected via dual fiber optic lines to two fiber distributed data interface (FDDI) loops. Communication between GCC's is accomplished through redundant bridge routers connecting adjacent FDDI loops. Wayside controllers are connected to the FDDI loops via dual fiber optic lines. Wayside controllers communicate with each other via fiber optic point-to-point lines. The wayside controllers communicate with the vehicles via an RF link.

5.3.10.2.2.13.b. PRELIMINARY HAZARD ANALYSIS

1. Global Control Center

Functions of a failed global control center will be assumed by the adjacent global control centers. Each adjacent GCC will control one of the failed GCC's FDDI loops through the bridge router. The system will function normally, and Class A maintenance required.

2. FDDI

The FDDI's are loops of dual fiber optic cable. If there is a single break in a loop, communication can still be accomplished. If there are multiple breaks, communication may be routed through the wayside controllers.

3. Bridge Router

Failure of a bridge router will cut communication of adjacent global controllers. Communication can be routed through wayside controllers at a slower rate. If GCC's cannot communicate at all, vehicles may not pass from one global control area into a new area.

4. Wayside Controller

Failure of a wayside controller means that a section of magway is no longer being controlled. A vehicle in an affected block will therefore loose guidance from the LSM, and will immediately deploy emergency brakes and come to a full stop. Global control will prevent other vehicles from entering the affected blocks.

5.3.10.2.3. EMERGENCY EGRESS

A hatch-type emergency exit will be provided at each end of the vehicle. The hatches will be designed to operate at all possible abnormal vehicle orientations in the magway. Emergency exits can be opened from inside or outside the vehicle.

After leaving the vehicle passengers can walk down the magway on the LSM winding to get to the nearest magport or to wait for an evacuation vehicle to arrive. A hinged stairway and platform arrangement is provided at intervals along the magway. It includes a small hinged stairway to climb over the box beam onto a landing. A larger stairway arrangement may be provided for reaching the ground. This stairway is counterbalanced and self-stowing. It is not accessible from the ground in the stowed position. The exit and stairway arrangement is shown in drawing S-11.

Emergency egress from passenger magports, substations and other conventional structures is not considered to be concept dependent. Standard regulatory codes for emergency egress apply to these structures and will be complied with in the design and construction.

5.3.10.2.4. FIRE PROTECTION

The Magneplane vehicle carries no fuel and can be quickly stopped on the magway to evacuate passengers in the event of an on-board fire. Passenger injuries due to on-board fire are improbable.

Vehicle fire protection will generally be in accordance with aircraft requirements. Particular features will include:

1. A minimum of three hand fire extinguisher located in the passenger compartment.

2. At least one hand fire extinguisher located in the operators compartment.

3. A ventilation system capable of removing smoke.

4. Vehicle finish materials which meet strict combustibility and flame requirements.

Fire protection at passenger magports, substations and other conventional structures is not considered to be concept dependent. Standard regulatory codes apply to fire protection of these structures and will be complied with in their design and construction.

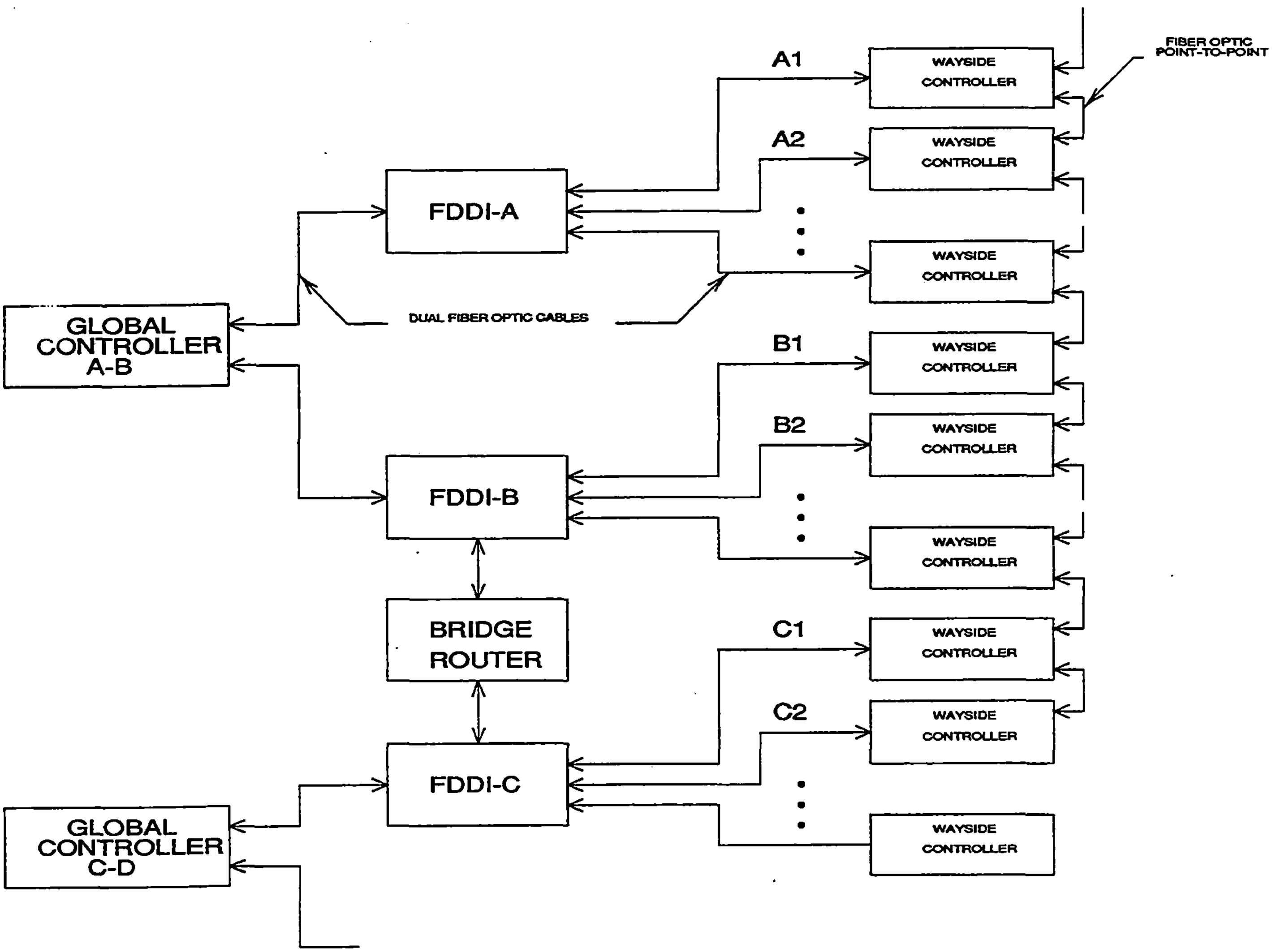


Figure 10 Simplified block diagram of the global and wayside control communication

5.3.11. LIFE CYCLE COST REPORT

CONTENTS

FIGURES

5.3.11.1. COST SUMMARY

The life cycle cost analysis is based on an idealized straight level route with magneplane having the passenger seats per hour in each direction as specified. The capital, energy and operation and maintenance costs were developed for capacity requirement.

The basic parameters used in the analysis are as follows:

160 KM (100 MI) Dual Magway
18 Operating Hours Per Day for 365 Days
50 Year Life
140 Passengers per Vehicle
Mid-1991 Dollars
A 10% Real Discount Rate and Constant Dollar Analysis

The baseline Route Capacity is 4,000 seats per hour each direction (8,000 total). See the Magneplane system specifications in volume 1 for the complete definition of the route which was costed.

The results of the cost analysis for 4,00 seats/hour are shown in Figure 2.

The incremental cost analysis to increase the rate capacity from 4000 to 8000, to 12,000 to 25,000 passenger seats per hour is summarized in Figure 1. The cost results show the comparison between the capacities based on the total capital costs and the annual energy and O&M costs

In addition to the baseline route costs, miscellaneous capital cost estimates have been developed for the following items, which do not appear in the baseline route.

Magnetic Switch Cost (Turnout)	$ 6,027,000
Cross Over	$11,808,000
Station Building Cost	$12,500,000

The cost results show the comparison between the capacities based on the total capital costs and the annual energy and O&M costs

COST RESULTS (X1000)

Seats/HR	4000	8000	12,000	25,000
Capital Invest.	$2,901,420	$3,308,816	$3,818,641	$5,037,855
Annual Energy	$ 64,863	$ 129,516	$ 194,168	$ 388,127
Annual O&M	$ 29,937	$ 42,105	$ 56,945	$ 93,370

The levelized annual costs have amortized the capital costs at 10% rate for 50 year period.

LEVELIZED ANNUAL COST (X1000)

Seats/HR	4000	8000	12,000	25,000
*Capital	$292,753	$333,860	$385,300	$508,320
Energy	$ 64,863	$129,516	$194,168	$388,127
O&M	$ 29,937	$ 42,105	$ 56,945	$ 93,370

* CRF (A/P, 10%, 50) = 0.1009

The cost in cents per passenger kilometers have been developed assuming an 18 hour operating day for 365 days per year.

COSTS PER PASSENGER KILOMETER (CENTS)

Seats/HR	4000	8000	12,000	25,000
Capital Invest.	3.48	1.98	1.53	0.97
Annual Energy	0.77	0.77	0.77	0.74
Annual O&M	0.36	0.25	0.23	0.18
Total	4.61	3.00	2.53	1.89

Figure 1 Summary of capacity upgrade costs for baseline route

BASIC COSTS		
	M$	**$M/km**
Capital Investment	2,901	18.1
Annual Energy	64	.4
Annual operating & Maintenance	30	.2

LEVELIZED ANNUAL COST			
	M$	**M$/km**	**cents/pas-km**
Capital	293	1.83	3.48
Energy	65	.40	.77
Operating & Maintenance	30	.18	.36
Total	338	2.41	4.61

Figure 2 Baseline route cost summary

5.3.11.2. CAPITAL COST

5.3.11.2.a. DISCLAIMER

Cost estimates prepared by Magneplane International and the Magneplane team represent our judgement as professionals in the engineering, manufacturing and construction industry. However, because many cost components of construction and manufacturing elements are not directly controlled by you or us, we do not warrant that final construction costs will match the estimates or evaluations we prepare.

WBS NO. DESCRIPTION	AVERAGE COST PER KM	TOTAL COST 160 KM
12 MAIN MAGWAY COSTS		
121 Elevated Magway Costs		
1211 Magway Cost		
Contingency 15%	1,379,500	222,010,000
1213 Double Elevated		
Magway Costs	9,196,800	1,480,050,000
Total WBS No. 121	10,576,300	1,702,060,000
15 SYSTEMWIDE ELECTRICAL AND COMMUNICATIONS COSTS		
151 systemwide electrical contingency		
Magway Elec.		
WBS 152 @ 15%	608,000	97,284,000
Comm. & Control Sys. (Incl. with WBS 153)		
Total WBS No. 151	608,000	97,284,000
152 Magway electrification costs		
1521 Overhead Distribution		
Line Costs	93,800	15,000,000
1523 Power Substation &		
Converter Station Costs	851,900	136,309,000
1526 LSM Winding Costs	3,107,800	497,244,000
Total WBS No. 152	4,053,500	648,553,000
153 COMMUNICATIONS AND CONTROL SYSTEM COSTS		
1531 - Global Control		
Facility Costs	8,400	1,343,000
1532 - Magway Communications		
Command and Control		
Systems Costs	298,500	47,760,000
Total WBS No. 153	306,900	49,103,000
Total WBS Nos. 152 & 153	4,360,400	697,656,000
Total WBS No. 15	4,968,400	794,940,000
18 VEHICLE COSTS		
182 Vehicle Cost	2,527,600	404,420,000
Total WBS No. 18	2,527,600	404,420,000
Total Cost Per Baseline Parameters	**18,072,300**	**2,901,420,000**

Figure 3 Capital cost itemized summary for baseline route

5.3.11.2.b. CAPITAL COST BASIS

Cost estimation format and detail: To the extent possible the detailed Work Breakdown Structure (WBS) and formulas described in the "MAGLEV Cost Estimation" report prepared by Parsons, Brinckerhoff, Quade & Douglas were used.

Pricing basis: All costs are in 1991 dollars and are based on or consistent with material prices and labor rates available in mid-1991. Construction costs are based on the national average costs per the 1991 issue of the R.S. Means Cost Data with appropriate adjustments as required.

Mark ups: The overhead and profit assumes that the installing contractor is the general contractor and is applied at 26%. The mobilization is carried at 5%.

Contingency: For this idealize route the recommended contingency has been carried as 15%.

Manufactured item: The pricing of the communication and control system, magneplanes and LSM winding do not have their contingency show. The contingency is carried with the pricing.

5.3.11.2.c. TOTAL ESTIMATED CONSTRUCTION COST

The summary of capital costs at 4,000 seats per hour per baseline parameters is given in Figure 3. Further details are given in Supplement B.

5.3.11.3. OPERATING AND MAINTENANCE COSTS

The operating and maintenance costs have been broken down into maintenance cost, energy costs and operating costs. The summary is found in 5.3.11.1. while the details are found in Supplement B. The following assumptions were used to develop the costs.

5.3.11.3.a. MAINTENANCE COST BASIS

1. Magway maintenance costs are based on four man work crew with an allowance for supervision, equipment floors and material maintaining 200 feet per day

2. The vehicle maintenance cost is based on one man-hour of maintenance for each hour of vehicle operation

3. The overhead distribution line power substation and the convertor stations maintenance costs are based on historical cost data for similar distribution plant facilities as 3% of capital cost

4. The LSM winding maintenance costs are based on periodic testing and repair of LSM winding block. One LSM winding section in each block is replaced each year

5. An allowance is provided for maintaining the equipment in the central control facility and the magway command and control system

5.3.11.3.b. ENERGY COST BASIS

1. Vehicle energy costs are based on the annual energy cost for the hours of operation of the vehicles at the energy cost of $0.0852 provided by the Government.

2. The energy costs for the global control center and the wayside control equipment are on a square foot basis.

5.3.11.3.c. OPERATING COST BASIS

1. The on-board personnel costs are based on an average trip of three hours which will require three labor shifts for coverage

2. The personnel costs to operate the global control center provided for two controllers and one supervisor for three shifts daily and two equipment maintenance personnel for one shift

5.3.11.4. ECONOMIC ANALYSIS METHODOLOGY

The economic evaluation of the Magneplane technology is based on present worth principles which are consistent with typical government and industry practices. Present worth analysis is a method for combining projected costs and revenues at different points in time into a single measure number using time value of money principles. This analysis includes all of the costs and revenues over the life cycle of the facility (also called "life cycle cost analysis"). The costs can be divided into two broad categories:

- FIXED COSTS

  Those costs which are relatively fixed over the service life of the facility and are not connected with the productivity of the facility,

- VARIABLE COSTS

  Those costs which are subject to inflation and/or vary with the throughput of passengers (speed or number of vehicles).

The fixed costs include the cost and recovery of capital, property taxes, insurance and income taxes. Property taxes, insurance and income taxes are assumed to be zero since public ownership is assumed. Annual fixed costs are accounted for in the analysis by multiplying the capital investment by the capital recovery factor (equation provided in section 5.3.11.4.1.).

Variable costs typically include the following:

Operating labor
Power or other fuel costs
Command and control operating costs
Maintenance labor and materials for the magway and vehicles
Other

Escalation of these variable costs is accounted for through a constant dollar analysis. Constant dollar analysis excludes the effect of inflation on the costs and the discount rate. This evaluation is typically done to address the hypothetical constant "purchasing power" of dollar amounts. "Real" escalation (greater than or less than the inflation rate) needs to be included. However, for this study, no real escalation is included as per direction from the U.S. Army Corps of Engineers.

The fixed and variable costs are included in the analysis as in the generalized model equation described below.

5.3.11.4.1. PWRR MODEL EQUATIONS

The present worth of the life cycle costs of the system provides a proper ranking of alternative systems which have the same passenger throughput. The present worth of the annual fixed costs and the annual variable costs are calculated by the following model equation:

$$PW_0 = TCR_0 + \sum_{k=1}^{N} \frac{VC_k}{(1+i)^k}$$

where:

PW_0= Present worth of costs at the beginning of service life (t = 0)

TCR_0=The total capital requirement at the beginning of service life (t = 0)

i= Interest rate (or discount rate) which represents the minimum acceptable return for the project.

N= Years of service life

k= Year index

VC_k= Annual variable charges for the k-th year in constant dollars. (Includes the effects of "real" escalation as required.)

The present worth values can then be used to compare alternative designs (given the same passenger throughput).

Levelized annual costs are another measure for comparing costs on a present worth basis. Levelizing is the term used to describe the procedure of arriving at a uniform series of periodic money amounts which is economically equivalent to a series of non-uniform money amounts over the same number and length of time periods. The value is calculated by multiplying the present worth of a series of costs by the A/P factor (or capital recovery factor) from standard interest tables to yield a uniform series (or levelized series) of money amounts. The capital recovery factor is also denoted as (A/P, i%, N), and can be calculated as:

$$\frac{i(1+i)^N}{(1+i)^N-1}$$

Results are reported in a variety of formats (total $, $/mile, $/passenger-mile) and types of results (present worth, levelized, first year) depending on the comparisons which need to be made. For example, results may be evaluated as levelized $/passenger-mile to compare options with different passenger throughputs.

A variety of sensitivity analyses have been produced to provide an understanding of the most significant cost drivers in the analysis.

5.3.11.4.2. ECONOMIC FACTORS

The following data and factors are used in the study.

Time Frames

Begin service life: mid-1991
Duration of service life: 50 years

Economic Data (Constant Dollar Analysis)

Analysis base date: mid-1991
Real discount rate (inflation effect removed): 10% (assumed)

Income taxes, property taxes and insurance: To simplify the analysis, public ownership will be assumed (at least for base case results). Therefore, income taxes are assumed to be zero. Information needs to be provided if there are to be any payments in lieu of income taxes.

Escalation rates: All variable costs are assumed to have total escalation rates which are the same as the inflation rate.

Derived Economic Factors

Capital recovery factor (A/P, 10%, 50) = 0.1009
Series present worth factor (P/A, 10%, 50) = 9.9148

5.3.11.5. BUSINESS STRATEGY

Magneplane has the best technology, the best people, and relationships with some of the best corporate partners. However, all of this by itself is not enough to ensure that the Company will attain a dominant technical position in the industry.

The challenge of creating a business plan for Magneplane is the challenge of developing and implementing the right strategy for success in an enormous new industry that does not yet exist. Within ten years the maglev industry will include many financially strong, well managed competitors who will be able to compete within some area of the market. The skills needed to succeed within the industry include ongoing research and development, the creation of increasingly sophisticated control systems, the design, redesign and manufacture of complex vehicles, the design of magways, the construction of maglev systems and magports, the operation of maglev mass transit systems, and real estate development.

The new industry will demand from its participants a broad array of talents, including the ability to work on the frontiers of science, industrial design, large scale manufacturing, large scale construction, marketing, customer service, and the political skills necessary to work with dozens of government entities. The Maglev industry, like the transportation industries that today utilize automobiles, trucks, trains, and airplanes, will not have a single company which is a dominant player in more than one area of the industry. Aircraft manufacturers do not run airlines, automobile manufacturers do not build roads and bridges, no major railroad dominates the U.S. freight market, and no major road carrier builds trucks.

Magneplane International must build a business based on its strength, capitalization, and an understanding of how to position itself for long term success. The Company will concentrate upon the development of leading edge proprietary technology which will be demanded by builders of magways, vehicle manufacturers, system operators, and others so that they can become competitive in their markets. These key Magneplane technologies and subsystems will be marketed, sold, and licensed all around the world.

Although Magneplane will not be an owner/operator of transportation systems, it is important to consider the economic model for operation. We have considered the Tampa-Orlando route as presently outlined by the Florida High Speed Ground Transportation office. They have projected 12,000 end to end passengers per day each way on this route. This system is 90 miles (150 km) long and will be built on or near an existing highway right of way (I-4). For the purpose of modeling revenue we will assume end to end travel only, elevated magway over relatively flat terrain.

Figure 4 shows a 30 year spread of costs and revenues for a simplified system. The fare assumed is $50. for a one way trip and was projected to lie between existing air and bus fares ($80. and $20. respectively) for the route.

Year	In	Out	Net	Δ Present Value
1	2.5	1.25 a	1.25	1.25
2	0	1.25	-1.25	-1.14
3	10	10 b	0	0.00
4	10	10	0	0.00
5	10	10	0	0.00
6	1000	1000	0	0.00
7	1000	1000	0	0.00
8	360 c	260 d	100	51.32
9	360	260	100	46.65
10	360	260	100	42.41
11	360	260	100	38.55
12	360	260	100	35.05
13	360	260	100	31.86
14	360	260	100	28.97
15	360	260	100	26.33
16	360	260	100	23.94
17	360	260	100	21.76
18	360	260	100	19.78
19	360	260	100	17.99
20	360	260	100	16.35
21	360	260	100	14.86
22	360	260	100	13.51
23	360	260	100	12.28
24	360	260	100	11.17
25	360	260	100	10.15
26	360	260	100	9.23
27	360	260	100	8.39
28	360	260	100	7.63
29	360	260	100	6.93
30	360	260	100	6.30

9.6%

a Marketing effort to secure franchise.
b Site layout, design, and permitting.
c 12,000 pass/day * $50. * 2 ways * 300 days/year
d inlcudes $178 M/year debt retirement at 8% for 25 years.

.08/mo

Figure 4 Cash flow projection for Tampa to Orlando route (amounts in millions)

5.3.12. COST ESTIMATE FOR SYSTEM DEVELOPMENT

CONTENTS

FIGURES

5.3.12.1. STATEMENT OF PURPOSE

The following report presents a development plan including the cost estimate for system development in such format as to meet the requirements of a prospective investor.

5.3.12.2. DEVELOPMENT PLAN EXECUTIVE SUMMARY

Magneplane International, Inc. develops, licenses, and markets technology, software, and hardware for its second generation super conducting maglev systems. The Magneplane system is more than an exciting new technology; it is a unique and practical solution for the world-wide transportation crises.

Magneplane is seeking partners and investors who want to help to build a new industry which will have enormous financial benefits for the Company and a substantial impact upon the transportation system and economic future of the United States.

The Magneplane concept was invented in 1969 by Henry Kolm and Richard Thornton of MIT, and was developed with support from MIT, Raytheon, United Engineers, Avco, Alcoa, and 3M. Additional funding was supplied by the National Science Foundation. From 1970 to 1975, an 80-member team composed of students, faculty, and engineers developed the concepts, a working model, and much of the basic technology for maglev vehicles.

In 1975, government funding was terminated and maglev development virtually stopped in the United States. Research and development continued in Japan and Germany. Teams in those nations adopted the linear synchronous motor and other features created by the Magneplane team. However, no other group has adopted Magneplane's unique configuration with the benefits which derive from its unique configuration and resilient suspension. Magneplane's management believes that the Company has the only existing technology which can form the basis of a revolutionary, practical, efficient, and profitable transportation system.

In 1990 the U.S. Maglev initiative was formed and four concept development contracts were awarded. Magneplane International received the largest of the four contracts, for $2,676,610. The product of this effort is a refined concept, additional patented proprietary technology, and a clearly defined solution to the transportation problem.

The problems of the U.S. transportation system include limited capacity, low average speed, congestion, unpredictable delays, pollution caused by the inefficient use of fossil fuels, high energy costs, wasteful land use, and high capital costs. Land and fuel resources are limited and we are no longer willing to pollute and deface our environment. These problem cannot be solved by doing more of the same or by small incremental improvements.

Transportation engineers have projected that by the year 2,000 highways up to forty lanes wide will be necessary in some areas to meet increasing demand. The enormous social and economic costs of expanding the existing system will force us to develop better systems. We have no choice but to develop advanced technology transportation systems.

The solution to the transportation problem is to dramatically increase the number of people traveling through the system per hour without increasing space and energy requirements. This can be done only by meeting three objectives simultaneously. First, increase the average speed of people traveling through the system, second, increase the capacity of the system and, third, increase the level of service of the system by increasing the number of points where passengers can enter and exit the system and by decreasing waiting time.

The Magneplane system maximizes passenger speed through its ability to move vehicles at speeds up to 300 m.p.h. along the right of way of existing interstate highways. This speed is possible due to the unique levitation system and proprietary control systems which make the vehicles stable at very high speeds. The magways can be banked to enable Magneplane vehicles to turn much like an airplane so that they can maintain very high speeds even through small radius curves of existing right-of-ways. High average speeds can be achieved over relatively short distances because the propulsion system and relatively light weight of the vehicles enables them to accelerate and decelerate quickly in all weather conditions.

The Magneplane magway is designed to be built on existing rights of way. It can be elevated, can be constructed within realistic tolerances, and incorporates high speed switching so that loading and unloading can take place off the main line without disrupting the flow of traffic. The system includes comprehensive and redundant fail safe mechanisms.

Magneplane attains the second objective, high capacity, by high speed, reduced intervals between vehicles, and through its dynamic scheduling system. Automated scheduling and control, redundant safety systems, loading and unloading on spur lines, and rapid acceleration and deceleration all contribute to high average speeds. Increased system capacity also derives from the increased passenger density which is the result of reducing the intervals between vehicles.

The system schedules vehicles based upon the demand as determined by ticket sales. Many vehicles are scheduled each hour and passengers are scheduled in small batches, up to a maximum of 140 passengers per vehicle. The system minimizes waiting time in magports, minimizes the time interval between vehicles, and has the flexibility to move people between many different destinations without making more than one or two stops on route. System capacity is maximized by the ability of the system to maintain 20 second headways and the ability to schedule service on demand to many small magports.

The third objective, increasing the service level by increasing the number of points people can enter and exit the system, is critical for any new mass transportation system to succeed. A mass system has to move people to and from their destinations. In most of the U.S., people do not travel from city center to city center. This is part of the reason why automobile travel is so dominant. To be successful, any new system will have to compete with automobiles. Dynamic scheduling, smaller vehicles, widely distributed magports, speed, cost, and off-line loading and unloading make Magneplane the only system which can compete successfully with automobiles.

Super conductor Maglev technology offers uniquely attractive solutions for U.S. and worldwide transportation needs. Construction of the next generation transportation system will be a massive major industrial venture, and it is vital that the U.S. play a major role. To compete in this arena, the U.S. must start the industrial development of Maglev very quickly. If not, Maglev production and sales- billions of dollars annually- will be foreign dominated.

The development of Maglev is inevitable. Magneplane has the best technology, people and corporate partners.

5.3.12.3. BACKGROUND OF HIGH SPEED PASSENGER RAILWAY SYSTEMS AND RECENT MAGNETIC LEVITATION TECHNOLOGY DEVELOPMENTS AND BENEFITS

During the first half of this century fast passenger rail travel was developed around the world. Some well known trains included the Orient Express in Europe, the 20th Century Limited in the United States, the Bullet trains in Japan, and the TGV system in France.

The limitations of railroad technology became more evident in the period after the Second World War. Railroads were neither fast nor flexible. The problem of capacity and the lack of flexibility limited passenger rail markets to commuter services in densely populated corridors. Air travel came to dominate long distance travel world wide and the population movement of people out of central cities led to the growing dominance of the automobile in much of the developed world. The trucking industry obtained a growing share of the long distance freight business.

By the late 1960's it was recognized that the speed of wheeled railroads is limited to between 150 to 200 miles per hour. No amount of engineering can make steel wheeled vehicles go faster reliably and economically because of the stress and wear limitations of steel itself, under realistically achievable magway accuracy.

Alternatives to the wheel were pursued seriously in a number of countries. Air cushion levitation was pursued in England, France, and the U.S., but was ultimately recognized as unworkable. In Germany, Krauss-Maffei and MBB were experimenting with attractive maglev vehicles, a technology invented in 1922.

In 1969, the Magneplane concept was invented by Henry Kolm and Richard Thornton at MIT. Over the next five years, an 80 man team led by Henry Kolm developed computer simulation models, performed towing tests, and built a fully operational superconducting 1/25th scale model magneplane running along a 400 foot magway at 60 mph. The team also invented the smart linear synchronous motor, established the basic concepts of repulsive maglev, invented the self banking sheet levitation system with integrated propulsion, invented the magnetic keel for roll stabilization, and the active passenger shielding system.

By 1974, most of the elements of the Magneplane concept had been developed, including the active damping system based on phase control of the LSM, supercritical helium refrigeration to achieve thermal stability in superconducting magnets without immersion in liquid helium. Most important, Kolm and his team had stopped thinking of maglev as a railroad. They began to design a transportation system as innovative as the technology it utilized.

When government funding was terminated in 1975, research and development virtually ceased in the U.S. However, German and Japanese groups have been funded continuously since the 1970's. These groups adopted Magneplane's linear synchronous motor and certain other features, but not its unique configuration or its flexibility. They have produced nothing more than prototypes for fast railroads.

In 1991, under a grant from the U.S. Maglev Initiative, Magneplane and three other U.S. efforts received funding. The results of that research have positioned Magneplane to begin the commercialization of its technology. With adequate funding, the team can begin construction of a revenue system in five years.

The Company now seeks to fund that commercial effort.

5.3.12.4. MAGNEPLANE TECHNOLOGY AND SYSTEM

5.3.12.4.a. MAJOR MAGNEPLANE DESIGN GOALS

Existing transportation technology is nearing saturation and cannot meet projected demands. Airlines have saturated the airspace at major hubs. Automobiles will require 40-lane interstate highways in a decade. Railroads, whether wheelborne or maglevitated, can handle about half as many passengers as one single highway lane; the faster they go, the less their capacity, and the less often they can stop. Radically new technology is needed.

The next revolution in transportation technology has begun, and will become the largest technology venture for several decades. Our economic security requires that we play a leading role in this venture, world-wide.

Magneplane International is designing the only transportation system proposed thus far that can meet projected demands, and help solve the problems of existing technology: congestion, pollution, environmental destruction, dependence on foreign oil, and unnecessary loss of lives. Magneplane therefore offers the only technology which can restore US leadership in transportation.

Magneplane's objective is not only to replace short-haul airlines, but primarily to reduce highway traffic, which carries more than 90 percent of passengers and freight along most corridors. This means providing a cost-effective, attractive alternative that people will actually use instead of their cars. If the automobile is partially displaced by a faster, safer, cheaper means for travelling and commuting, driving will be fun again, and we can better protect our health and environment. Magneplane systems will permit measures like the establishment of green-belt zones to revitalize urban centers by reduced congestion, frustration and lost productivity.

Magneplane technology will also enable the United States to develop world leadership in high-speed ground transportation, thereby restoring our balance of trade, our industry, and our jobs.

Our principal design goals are the following:

1. *cruising speed of 300 mph, high average speed, low waiting time, non-stop service when possible*
2. *capacity of up to 25,000 passengers per hour on a single magway (equal to three highway lanes)*
3. *transportation alternative to both cars and planes for trips as long as 400 miles*
4. *ride quality as good or better than airplanes*
5. *safe, reliable, and operational under all weather conditions*
6. *no new corridors - should be built along existing highways*
7. *flexibility in upgrading capacity and service*
8. *points of access where people live and work, lower use of intermodal connections than required by airplanes*

5.3.12.4.b. HOW OUR DESIGN MEETS THESE GOALS

We propose a computer-controlled continuous flow system:

- We will build **small magports** at shopping malls, industrial parks, city centers, and any other place where people go in great numbers. There is no reason to limit maglev use to a few huge hubs. Small off-line magports will be served without interrupting the flow of magplanes along the principal corridor.

- We will connect the magports with a network of **magways built along existing highways.** New land for straight routes is simply not available in places where maglev is needed most. The Magneplane system allows magplanes to bank in curves like airplanes to provide a comfortable ride at high speeds.

- We will run **single magplanes,** not trains. Magplanes will be dynamically scheduled: A central computer will plan the routes of each vehicle in response to ticket purchases, so that passengers will get fast service directly to their destination with as few stops between as possible. With long trains, small magports are not possible, nor is dynamic scheduling. Trains cannot stop often enough to be useful.

The magplane is propelled by a powered magway; vehicles ride a travelling wave, like surfboards; they can follow at close headways without colliding. Super-conducting magnets on board the vehicle interact with the magway to produce both lift and thrust.

5.3.12.4.c. LEVITATION

Superconducting levitation magnets at the bow and stern produce strong magnetic fields underneath the vehicle. When the magnets move, their fields induce image currents in a 2 cm thick aluminum sheet in the magway. These image currents behave exactly like mirror images moving with the vehicle magnets, and therefore repel them, producing a lift force.

Sheet levitation (as the effect has been called) can produce a smooth ride at a height of several inches above the magway, even when the magway is rough. This magnetic spring is very soft, but becomes very stiff as the vehicle is pushed toward the magway and thus prevents contact. Oscillations are prevented by an active damping system (smart shock absorber) described below.

5.3.12.4.d. PROPULSION AND BRAKING.

The Magneplane vehicle is propelled by a *linear synchronous motor* (LSM), which resembles a "brushless DC motor", stretched out along the magway. In a rotary motor, a rotor with coils follows a rotating magnetic field generated by stator coils which surround the rotor.

In the case of Magneplane, the rotor coils are aboard the vehicle, and the stator coils are in the magway. When they are powered with AC current, the magway coils produce a *traveling wave* of magnetic field. The speed of the wave depends on the frequency of the AC current. This frequency, and thus the vehicle speed, is controlled by wayside power units which resemble the wayside transformers in a conventional railroad. These units can accelerate, maintain speed, or decelerate the vehicle.

Each unit powers the LSM over a block of up to 2 km. Only one vehicle occupies a block at any given time, so there are never two vehicles riding the same traveling wave.

The wayside power units communicate with the magplane travelling in their particular block, controlling its speed. They also communicate with the central controller which manages all traffic in the entire system.

5.3.12.4.e. MAGWAY

The Magneplane magway (or magway) can be built on grade. It can also be elevated inexpensively because it carries only one twentieth the live load of a railroad trestle. This is an important advantage, because grade crossings cannot be used at the speed and frequency of magplanes.

The upper surface forms a circular trough designed for passive self-banking in curves (see below). The trough consists of three parts: The center contains the linear synchronous motor winding, which is a meander coil potted in reinforced composite; It is flanked on each side by a curved aluminum levitation plate forming a trough of circular cross section. This trough is supported by an integral aluminum space frame, or where long spans are necessary by a separate girder of concrete or steel.

5.3.12.4.f. COORDINATED CURVES

Magneplanes can perform *coordinated curves,* just like airplanes. A perfectly coordinated curve is a banked curve in which there is no sideways force on the passengers - they are not aware of any banking unless they look out the window. Coordinated curves happen automatically in Magneplanes because they are free to roll in the circular magway trough, and the vehicle's own mass provides the rolling moment.

Curved magways are built for a particular optimal speed (the design speed) at each point. At the design speed, the vehicle rolls such that its propulsion magnets are directly over the linear synchronous motor windings. Significant deviation from the design speed is acceptable, without a loss of propulsion power or ride quality.

5.3.12.4.g. VEHICLE SWITCHING

Magplanes must enter and exit the main magway trunk at high speed, without slowing down the flow of traffic. A mechanical switch which requires bending a long section of magway was found to be too slow at minimum headways of twenty seconds to permit detecting a malfunction and taking corrective action. It was also found to be too sensitive to icing and too maintenance-intensive.

We have therefore invented and verified a magswitch without moving parts which can be actuated and confirmed in a fraction of a second, requires no power to operate, and is fail-safe in the event of power failure.

The magway trough widens to form a side-branch, and the vehicle is guided between the main trunk and the branch by selectively opening or short-circuiting two sets of passive coils by means of relays. These coils are the magnetic equivalent of the mechanical "frog" used in conventional railroad switches. They can be default-wired for the vehicle to either continue, or exit the magway in the event of power failure.

5.3.12.4.h. CAPACITY AND UPGRADE

Two sizes of Magneplane vehicles: a 45-passenger and a 140-passenger vehicle have been designed. Small vehicles may be used initially. As part of an integrated upgrade plan, large vehicles (requiring more power) will be built later to provide higher capacity.

5.3.12.4.i. COOLING

The Magneplane superconducting magnets require cooling to 8 degrees Kelvin. The Magneplane cryogenic refrigerator circulates coolant (supercritical helium, helium above its critical pressure where it cannot form bubbles) through the conduit which surrounds the superconducting wire. "Cable-in-conduit" magnets of this type were developed by our team and are used in most of the largest superconducting magnets world-wide. The technique eliminates the need for immersion in liquid helium. Magnets are surrounded only by a vacuum container and a nitrogen-cooled heat shield.

5.3.12.4.j. ON-BOARD POWER

A high-frequency, backward-travelling wave superposed on the propulsion wave will induce about 200 kW of AC power in on-board pickup coils. It will be converted to standard line frequency and used to power on-board actuators, lighting, heating and air conditioning equipment.

5.3.12.4.k. LANDING GEAR

Magneplane's landing gear uses *air-lubricated pads* instead of wheels. These pads are lined with an anti-friction material and extended by actuators capable of lifting the vehicle to levitation height. A compressor forces air through holes in the bottom of these pads to generate an air cushion. This type of gear is desirable at landing speeds because it is more durable and dependable than wheels and requires less maintenance. It also facilitates magport handling by permitting lateral motion and rotation on a flat surface.

5.3.12.4.el. EMERGENCY BRAKES

Vehicle braking is normally done by the LSM, which can achieve more than 0.2 gee of acceleration or deceleration, converting about 80 percent of braking energy into useful power (regenerative braking). In case of LSM power failure, emergency brakes are used. High-friction skids are extended by actuators resembling the landing pads and produce up to 0.65 gee of emergency deceleration. Braking energy is dissipated in a length of magway which can absorb much more energy than a disk brake. Even the most advanced multi-disk, multi-caliper aircraft brakes of acceptable size would not suffice for a single emergency stop from 300 mph.

5.3.12.4.m. ACTIVE DAMPING

Magnetically levitated vehicles of any type have no inherent damping mechanisms and will oscillate at their resonant frequencies. Magneplanes exhibit slow oscillations (0.5 - 2 Hz) in all principal modes of motion (heave, pitch, yaw, sway, roll, and thrust). Vibrations at these frequencies are eliminated by an *active damping system.* Two mechanisms for damping are employed: the phase of the LSM is shifted to generate vertical forces which counteract vertical oscillations (heave), and aerodynamic surfaces oppose pitch, yaw and roll oscillations. This active system prevents oscillations before they start, unlike a passive shock-absorber which can only damp oscillations after they have developed.

5.3.12.4.n. CONTROLS

Magneplanes use a multi-tiered self-inspecting fail-safe control system. There are three tiers of control hierarchy: *on-board, wayside* and *global.*

The **on-board control system** manages the landing gear, airfoils, emergency braking, door operating, and other vehicle-related functions. It monitors vehicle attitude, acceleration in all modes, and magway proximity. It calls the wayside power unit for appropriate correcting forces and moments to maintain ride quality by adjusting the phase and frequency of the LSM current and by actuating aerodynamic surfaces. Its input is a multi-sensor platform, and its output controls the wayside power conditioning units and the on-board control actuators for landing gear, brakes, doors, etc. The history of vehicle performance may be used to instruct subsequent vehicles about optimal ways to respond to magway conditions and to monitor the structural integrity of the magway.

A **wayside control system** in each magway block manages the LSM in that block. Its inputs come from the on-board control system, and from the Global control system. The wayside system also controls vehicle switching in any block that contains a magnetic vehicle switch.

The **global control system** manages the overall traffic on a continuous basis. It always maintains headways and speeds for all vehicles, plans routes so as to avoid bottlenecks, ensures optimum vehicle availability, and solves emerging traffic problems. It also responds to ticket purchases by scheduling vehicle destinations, and assigning passengers to vehicles. It receives input from the accounting/ticketing system at each magport and each of the wayside control systems.

A **back-up** system relies on global positioning to ensure that vehicle position information is preserved in the event of power or communications failure.

5.3.12.4.o. TAKE-OFF AND LANDING MODES

Induced repulsion will not suffice to lift the vehicle at speeds below about 18 m/s (40 mph), and available thrust will not suffice to reach take-off speed at zero gap. Drag is too high, and the magplane will not "get on the step. The landing gear must therefore lift the vehicle to levitation height and hold it there until take-off speed has been reached.

Lifted by air-lubricated landing pads, take-off will require only several hundred meters, or about half the length of a typical runway.

5.3.12.5. THE UNIQUE CAPABILITIES OF THE MAGNEPLANE SYSTEM

The inherent limitations of other mass transportation technologies prevents them from providing the solution to the transportation problem. The following explains why only the Magneplane concept and technology can provide a solution.

To solve the transportation problem a transportation system must achieve three objectives:

1. High speed (origin to destination)
2. High capacity
3. High level of service (proximity and frequency)

These are straightforward objectives but they are by no means independent. In fact, using existing transportation technology, the maximization of one can be accomplished only by compromising another.

For example, suppose the operators of the French TGV system wish to increase the system carrying capacity from Paris to Brest during peak hours. They may do this only by pursuing two strategies. First, they can add more trains with the same number of passengers on each train; or second, they may put more passengers on existing trains and run the trains on the same schedule.

Either method has inevitable unintended consequences. The first solution, adding additional trains, will reduce the interval between trains, "headway", because more trains will occupy the same section of track during the same time period. Given the minimum headway requirements imposed by the limitations imposed by steel wheels, it will be necessary to reduce the velocity of each train to maintain existing safety standards. This method of increasing capacity will reduce the speed of transit.

The second solution, adding more passengers to each train, will cause the train sets to become heavier. The additional weight will reduce the ability of the train to accelerate and decelerate. The TGV already makes very few stops and even today does not fulfill the third objective, high service levels. Making train sets even larger will further decrease the level of service.

Managers of rail systems prefer longer train sets to achieve a high system capacity with high speed service. This is because they have no choice. The level of service must decline with each incremental increase in train set length. The more people there are on a single train set, the more costly it is to stop the train for a few people to get off and on. Large train sets are efficient only when most of the passengers get on at one location and get off at another.

The Magneplane system offers a whole new set of parameters. Magplanes will be small and light. Magplanes will travel about five times faster than U.S. trains and automobiles. The system's ability to switch single magplanes into and out of the traffic flow without disrupting the flow and the resulting scheduling ability makes magplanes resemble automobiles more than trains. High levels of service are achieved by independently targeting magplanes from source to destination. Since magplanes are light and are externally propelled they can accelerate and decelerate rapidly and can operate safely at short headways. High speed, high capacity, close magport spacing and high service frequency all become compatible.

5.3.12.6. ACTUAL MAGNEPLANE TRAVEL TIMES FOR FLORIDA CORRIDOR

Actual travel times for the Orlando to Tampa corridor are shown in Figure 1.

From: \ To:	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. St. Petersburg		4.0	6.1	8.6	6.5	12.6	13.5	20.1	24.1	22.3	27.6	31.0	27.8	30.3
2. Tampa DT			2.4	4.9	2.8	9.0	9.8	16.5	20.5	18.7	23.9	27.3	24.2	26.7
3. Tampa airport				2.8	4.9	11.0	11.9	18.5	22.6	20.8	26.0	29.4	26.3	28.8
4. North Tampa					7.4	13.5	14.4	21.0	25.1	23.3	28.5	31.9	28.8	31.3
5. Brandon						6.5	7.3	14.0	18.0	16.2	21.4	24.8	21.7	24.2
6. Plant City							2.3	8.9	13.0	11.2	16.4	19.8	16.7	19.2
7. Lakeland								7.0	11.0	9.2	14.4	17.9	14.7	17.2
8. Winter Haven									9.4	7.6	12.8	16.2	13.1	15.6
9. Kissimmee										3.8	9.0	12.4	9.3	11.8
10. Lake Buena Vista											5.6	9.0	5.8	8.3
11. Orlando airport												8.2	5.1	7.6
12. Winter Park													3.5	6.0
13. Orlando DT														2.8
14. Altamonte Spr														

Figure 1 Actual Magneplane travel times for Tampa-Orlando corridor - minutes

5.3.12.7. POTENTIAL MARKET OPPORTUNITY - U.S. AND INTERNATIONAL

The successful development of a new transportation system of the magnitude envisioned by the Company is dependent upon substantial support of the federal government and private industry. The railroads , air transportation, and the Interstate Highway system were all dependent upon government support. The federal government has already contributed significant funding to this effort and is committed to additional funding. The government has taken a strong position in support of the maglev technology that today is proprietary to Magneplane International.

"It is the policy of the United States to establish in the shortest time practicable a United States designed and constructed magnetic levitation transportation technology capable of operating along Federal-aid highway rights-of-way, as part of a national transportation system of the United States." - From the Intermodal Surface Transportation Efficiency Act of 1991 (Public Law 102-240).

No other maglev system is capable of operating at 300 miles per hour along the Interstate Highway rights-of-way.

Today maglev systems are in the planning stages in Florida. Texas, California, and the Northeast Corridor. All have the potential to have funded projects underway before the year 2,000.

The Company projects that it will cost approximately $2 billion to build 100 miles of a two way maglev system, plus another $1 billion for magports and $1 billion for vehicles, or $4 billion total. The Company projects that within the next twenty years, 5,000 miles of maglev magways will be constructed within the United States. The total cost of this undertaking will be approximately $200,000,000,000. In addition, thousands of maglev vehicles will be produced for mass transit systems, for inter city travel of up to 400 miles, and smaller private vehicles will be built for private corporations.

It has been projected that there will be over 2,000 miles of maglev in operation in the world by the end of this century, with a total of almost one trillion dollars spent. We believe that maglev will generate 10,000 jobs for every billion dollars spent to build and operate maglev systems. Ultimately, the United States market will be only a fraction of the world market. Clearly this is an enormous opportunity. This nation cannot afford to allow others to develop and capture this market. and U.S. corporations cannot afford to let others reap the profits of this new industry.

5.3.12.8. MAGNEPLANE REVENUE SOURCES AND PROJECTED INCOME

Magneplane will derive its income from five primary sources:

1. **Licenses and royalties-**

The Company will sell master licences to companies to build and operate transportation systems using Magneplane technology. These license fees will be paid from the time the license is granted through the first ten years of operation. These fees have been projected at $2,000,000 per year for a 100 mile system.

In addition, the Company will license others to manufacture maglev hardware, including vehicles, magways, and command and control systems. It is anticipated that the Company will develop joint ventures and partnership relationships with other corporations and that the partners will develop as yet unspecified financial arrangements in lieu of a standard license fee for the use of Magneplane technology.

2. **Sale of software and hardware-**

The Company intends to continually develop and produce some key elements of the Magneplane technology. This technology will include, but will not be limited to, scheduling, process technology, and command and control sub-systems.

3. **On-site engineering services-**

The company will provide on-site engineering and support services for operating companies and for manufacturers of Magneplane licensed systems. This support will include support for constructing, maintaining, operating and upgrading systems and sub-systems.

4. **Profit participation-**

The company will profit through equity positions it acquires both in operating companies and in joint ventures with manufacturers of maglev systems.

5. **Government contracts-**

The Company will receive a substantial part of its income, particularly during its first five years of operation, from government contracts to undertake research and development projects.

The projections in this business plan are extremely conservative. Total sales are projected to be $30,700,000 during the tenth year of operation. These projections do not include income from profit participation, hardware sales, or royalty payments from manufacturers of vehicles, magways, or command and control systems.

5.3.12.9. PROJECTED DEVELOPMENT COSTS

The projected development costs have been segregated from the financial projections for Magneplane. This has been done because it is anticipated that the development costs for the first prototype will be undertaken as a joint effort with several partners and that federal funds will also be used. The potential partners include private investors, corporate investors, and potential contractors. Contributions of the partners could include an investment in Magneplane International, an investment in an operating company, financial investment in a joint venture, or the funding of a part of the project which would be undertaken in the partners facilities.

The projected development costs for the first operating full scale prototype have been included in the financial section as the "Fast Track" plan. These projected costs are for the Company to create a working prototype in the shortest possible time.

All work and testing of the prototype would be completed by the end of 1998. The prototype could either serve to demonstrate the technology or it could be built in a location that would make it possible to incorporate it into a commercial system after completion.

The total cost of the development of the first prototype system is projected to be approximately $180 million.

5.3.12.10. BUSINESS STRATEGY

Magneplane has the best technology, the best people, and relationships with some of the best corporate partners. However, all of this by itself is not enough to ensure that the Company will attain a dominant position in the industry.

The challenge of creating a business plan for Magneplane is the challenge of developing and implementing the right strategy for success in an enormous new industry that does not yet exist. Within ten years the maglev industry will include many financially strong, well managed competitors who will be able to compete within some area of the market. The skills needed to succeed within the industry include ongoing research and development, the creation of increasingly sophisticated control systems, the design, redesign and manufacture of complex vehicles, the design of magways, the construction of maglev systems and magports, the operation of maglev mass transit systems, environmental and land use planning, and real estate development.

The new industry will demand from its participants a broad array of talents, including the ability to work at the frontiers of science, industrial design, large scale manufacturing, large scale construction, marketing, customer service, and the political skills necessary to work with dozens of government entities. The Maglev industry, like the transportation industries that today utilize automobiles, trucks, trains, and airplanes, will not have a single company which is a dominant player in more than one area of the industry. Aircraft manufacturers do not run airlines, automobile manufacturers do not build roads and bridges, no major railroad dominates the U.S. freight market, and no major road carrier builds trucks.

Magneplane International must build a business based on its strengths, capitalization, and an understanding of how to position itself for long term success. The Company will concentrate upon the development of leading edge proprietary technology which will be demanded by builders of magways, vehicle manufacturers, system operators, and others so that they can become competitive in their markets. These key Magneplane technologies and sub-systems will be marketed, sold, and licensed all around the world.

Magneplane International will build a business by developing relationships with corporate partners, maintaining control of key elements of the technology and design specifications, manufacturing key high value added components, and licensing the rights to use Magneplane systems and proprietary technology to corporations which have the capability and the commitment to create and operate a mass transit system to the Company's standards.

Magneplane must exploit its investment in its proprietary technology and patents. The Company will limit its efforts to those elements of the industry which are technology driven, which best utilize the talents of the key people in the Company, and which are critical to maintaining the Company's technological leadership role.

Magneplane International will manufacture certain key subsystems for commercial Magneplane systems and will charge license fees to corporations who manufacture maglev systems using the Company's proprietary technology. The Company will also generate income from the sale and licensing of Magneplane superconducting technology, control systems, and software which will be used in industries other than maglev and mass transit.

The Company will not become directly involved in those facets of the industry which will require enormous capital investments, which depend upon technologies with which key people in the Company have limited experience, and which rely upon business and marketing skills which are beyond management's experience. The Company will have a partnership interest but no direct involvement in real estate development, the construction of complete Magneplane vehicles or complete magways, or the construction or operation of commercial mass transit systems.

Magneplane will benefit from the operation of commercial mass transit systems through royalty payments based upon passenger revenues and through equity positions in ventures set up with corporate partners and maglev transit companies.

The strategy described in financial spreadsheets which follow corresponds to the test program in Section 5.3.9.2.b.3. It is based on winning a contract to build a 150 km Magneplane system between Tampa Bay area and Orlando area, and serving 16 population centers. To establish credibility for Magneplane technology, we propose to build a 2 km test track on a tract of land, which has already been provided free of charge by American Cyanamid Corporation. It is located along I-4, near Lakeland, about half way between Tampa and Orlando.

5.3.12.11. FINANCIAL SPREADSHEETS DESCRIBING MAGNEPLANE DEVELOPMENT PLAN

See pages following.

MAGNEPLANE INTERNATIONAL, INC.					
FAST TRACK	OCT	JAN	APRIL	JULY	
10/1/92-9/30/93	1ST QUARTER	2ND QUARTER	3RD QUARTER	4TH QUARTER	TOTAL
USES OF CASH:					
CONTROLS & COMMUNICATION					
PRELIM HEAVE CONT'L MODEL	20,800	19,200	0	0	40,000
DEVEL'P SENSOR & COMM PLAT	81,250	81,250	81,250	6,250	250,000
VEHICLES					
DEV MK I MAGNET MODULES	1,919,047	1,919,047	1,919,047	442,857	6,199,998
DESIGN PLAT, MECH	100,000				100,000
ASSEMBLE TEST PLATFORM			320,000	480,000	800,000
ELECTRIFICATION					
DEV LSM & POWER COVERSION	2,995,395	2,995,395	2,995,395	1,013,826	10,000,011
SITE ELECTRIC DES & CONSTR	28,886	28,886	28,886	13,332	99,990
GUIDEWAY					
DESIGN GUIDEWAY	60,000	0			60,000
SITE & BUILD TEST TRACK	1,714,284	5,571,423	5,571,423	2,142,855	14,999,985
LINEAR VEHICLE TEST PROGRAM	0	0	0	21,336	21,336
CONTROLS & COMMUNICATIONS					
6 DOF MODEL	35,750	35,750	35,750	35,750	143,000
MAGNETIC FIELD ANALYSIS	235,625	235,625	235,625	235,625	942,500
HEAVE CONTROL MODEL	20,800	19,200			40,000
SWITCH MODELING		10,000	32,500	32,500	75,000
BLOCK CONTROLS W HANDOFF					0
ADVANCED ON-BOARD SENSORS					0
ASSEMBLE SENSOR HARDWARE					0
VEHICLE					
MARK II MAGNET BOGIE	0	84,286	1,095,718	1,095,718	2,275,722
H-PAD DEVELOPMENT	182,000	168,000			350,000
A-PAD DEVELOPMENT	182,000	168,000			350,000
GEAR DEVELOPMENT	0	128,000	208,000	208,000	544,000
DESIGN & FAB SHIELDING	0			160,000	160,000
UPDATE TEST PLATFORM	133,333				133,333
ELECTRIFICATION					0
ADD 2 BLOCK HARDW & CONTROL					0
GUIDEWAY					
MAG SWITCH DES./CONSTR					0
DESIGN & BUILD CURVE					0
ADVANCED LINEAR VEHICLE TEST					0
CONTROLS & COMM					
AERO CONTROLS DESIGN					0
INTEGRATED ATTITUDE CONT'L					0
FULL ON BOARD COMMUNICA					0
ROUTE MODEL					0
GLOBAL CONTROLS, SPEC & PRO					0
VEHICLE					
AERO CHARACTERIZATION				22,856	22,856
POWER PICK UP DESIGN					0
ON-BOARD POWER SYS					0
ON-BOARD SYSTEM DESIGN					0
VEHICLE FUSELAGE				1,280,000	1,280,000
VERIFY VEHICLE STRUCTURE					0
ASSEMBLE FULL CAP PROTO					0
ELECTRIFICATION					
ALL DYNAMIC POWER SYSTEM				14,000	14,000
MECHANICAL & THERMAL LSM				7,840	7,840
ADVANCED LSM DESIGN					0
ADVANCED LSM FAB & INSTALL					0
GUIDEWAY					
LEV PLATE THERMAL MODEL				32,000	32,000
BOX BEAM CONSTR METHODS					0
FULL CAPACITY TEST TRACK					0
VEHICLE TEST PROGRAM					0
TOTAL FOR PERIOD	7,709,170	11,464,062	12,523,594	7,244,745	38,941,571
CASH OUT FOR PERIOD	5,142,017	10,213,683	12,170,770	9,002,602	36,529,071
PAYABLES	2,567,154	3,817,533	4,170,357	2,412,500	
CHANGE	2,567,154	1,250,379	352,824	-1,757,857	

MAGNEPLANE INTERNATIONAL, INC.					
FAST TRACK	OCT	JAN	APRIL	JULY	
10/1/93-9/30/94	1ST QUARTER	2ND QUARTER	3RD QUARTER	4TH QUARTER	TOTAL
USES OF CASH:					
CONTROLS & COMMUNICATION					
PRELIM HEAVE CONT'L MODEL					0
DEVEL'P SENSOR & COMM PLAT					0
VEHICLES					
DEV MK I MAGNET MODULES					0
DESIGN PLAT, MECH					0
ASSEMBLE TEST PLATFORM					0
ELECTRIFICATION					
DEV LSM & POWER COVERSION					0
SITE ELECTRIC DES & CONSTR					0
GUIDEWAY					
DESIGN GUIDEWAY					0
SITE & BUILD TEST TRACK					0
LINEAR VEHICLE TEST PROGRAM	346,671	346,671	346,671	346,671	1,386,684
CONTROLS & COMMUNICATIONS					
6 DOF MODEL	35,750	35,750	5,500		77,000
MAGNETIC FIELD ANALYSIS	235,625	235,625	36,250		507,500
HEAVE CONTROL MODEL					0
SWITCH MODELING	25,000				25,000
BLOCK CONTROLS W HANDOFF	4,000	52,000	44,000		100,000
ADVANCED ON-BOARD SENSORS	33,333	433,329	33,333		499,995
ASSEMBLE SENSOR HARDWARE		4,000	52,000	44,000	100,000
VEHICLE					
MARK II MAGNET BOGIE	1,095,718	1,095,718	1,095,718	337,144	3,624,298
H-PAD DEVELOPMENT					0
A-PAD DEVELOPMENT					0
GEAR DEVELOPMENT	208,000	208,000	208,000	32,000	656,000
DESIGN & FAB SHIELDING	260,000	80,000			340,000
UPDATE TEST PLATFORM				1,066,664	1,066,664
ELECTRIFICATION				1,300,000	1,300,000
ADD 2 BLOCK HARDW & CONTROL			400,000	1,300,000	1,700,000
GUIDEWAY					
MAG SWITCH DES./CONSTR	150,000	1,950,000	1,950,000	1,950,000	6,000,000
DESIGN & BUILD CURVE		1,846,152	2,999,997	1,153,845	5,999,994
ADVANCED LINEAR VEHICLE TEST					0
CONTROLS & COMM					
AERO CONTROLS DESIGN			32,000	52,000	84,000
INTEGRATED ATTITUDE CONT'L					0
FULL ON BOARD COMMUNICA					0
ROUTE MODEL					0
GLOBAL CONTROLS, SPEC & PRO					0
VEHICLE					
AERO CHARACTERIZATION	37,141	37,141	2,857		77,139
POWER PICK UP DESIGN					0
ON-BOARD POWER SYS					0
ON-BOARD SYSTEM DESIGN					0
VEHICLE FUSELAGE	2,080,000	2,080,000	2,080,000	2,080,000	8,320,000
VERIFY VEHICLE STRUCTURE					0
ASSEMBLE FULL CAP PROTO					0
ELECTRIFICATION					
ALL DYNAMIC POWER SYSTEM	22,750	22,750	10,500		56,000
MECHANICAL & THERMAL LSM	12,740	12,740	12,740	12,740	50,960
ADVANCED LSM DESIGN					0
ADVANCED LSM FAB & INSTALL					0
GUIDEWAY					
LEV PLATE THERMAL MODEL	52,000	52,000	4,000		108,000
BOX BEAM CONSTR METHODS					0
FULL CAPACITY TEST TRACK					0
VEHICLE TEST PROGRAM					0
TOTAL FOR PERIOD	4,598,728	8,491,876	9,313,566	9,675,064	32,079,234
CASH OUT FOR PERIOD	5,479,852	7,195,458	9,039,943	9,554,685	31,269,938
PAYABLES	1,531,376	2,827,795	3,101,417	3,221,796	
CHANGE	-881,124	1,296,418	273,623	120,379	

MAGNEPLANE INTERNATIONAL, INC.					
FAST TRACK	OCT	JAN	APRIL	JULY	
10/1/94-9/30/95	1ST QUARTER	2ND QUARTER	3RD QUARTER	4TH QUARTER	TOTAL
USES OF CASH:					
CONTROLS & COMMUNICATION					
PRELIM HEAVE CONT'L MODEL					0
DEVEL'P SENSOR & COMM PLAT					0
VEHICLES					
DEV MK I MAGNET MODULES					0
DESIGN PLAT, MECH					0
ASSEMBLE TEST PLATFORM					0
ELECTRIFICATION					
DEV LSM & POWER COVERSION					0
SITE ELECTRIC DES & CONSTR					0
GUIDEWAY					
DESIGN GUIDEWAY					0
SITE & BUILD TEST TRACK					0
LINEAR VEHICLE TEST PROGRAM	346,671	53,334			400,005
CONTROLS & COMMUNICATIONS					
6 DOF MODEL					0
MAGNETIC FIELD ANALYSIS					0
HEAVE CONTROL MODEL					0
SWITCH MODELING					0
BLOCK CONTROLS W HANDOFF					0
ADVANCED ON-BOARD SENSORS					0
ASSEMBLE SENSOR HARDWARE					0
VEHICLE					
MARK II MAGNET BOGIE					0
H-PAD DEVELOPMENT					0
A-PAD DEVELOPMENT					0
GEAR DEVELOPMENT					0
DESIGN & FAB SHIELDING					0
UPDATE TEST PLATFORM	933,331				933,331
ELECTRIFICATION	700,000				700,000
ADD 2 BLOCK HARDW & CONTRO	300,000				300,000
GUIDEWAY					
MAG SWITCH DES./CONSTR					0
DESIGN & BUILD CURVE					0
ADVANCED LINEAR VEHICLE TEST	533,336	866,671	866,671	866,671	3,133,349
CONTROLS & COMM					
AERO CONTROLS DESIGN	16,000				16,000
INTEGRATED ATTITUDE CONT'L			56,000	91,000	147,000
FULL ON BOARD COMMUNICA	40,000	60,000			100,000
ROUTE MODEL	153,848	250,003	250,003	250,003	903,857
GLOBAL CONTROLS, SPEC & PRO	76,920	124,995	124,995	124,995	451,905
VEHICLE					
AERO CHARACTERIZATION					0
POWER PICK UP DESIGN	80,000	130,000	130,000	60,000	400,000
ON-BOARD POWER SYS			80,000	120,000	200,000
ON-BOARD SYSTEM DESIGN			80,000	120,000	200,000
VEHICLE FUSELAGE	2,080,000	2,080,000	2,080,000	2,080,000	8,320,000
VERIFY VEHICLE STRUCTURE				160,000	160,000
ASSEMBLE FULL CAP PROTO					0
ELECTRIFICATION					
ALL DYNAMIC POWER SYSTEM					0
MECHANICAL & THERMAL LSM	12,740	12,740	12,740	4,900	43,120
ADVANCED LSM DESIGN		45,500	24,500		70,000
ADVANCED LSM FAB & INSTALL			1,600,000	5,200,000	6,800,000
GUIDEWAY					
LEV PLATE THERMAL MODEL					0
BOX BEAM CONSTR METHODS			28,000	42,000	70,000
FULL CAPACITY TEST TRACK				11,000,000	11,000,000
VEHICLE TEST PROGRAM					0
TOTAL FOR PERIOD	5,272,846	3,623,243	5,332,909	20,119,569	34,348,567
CASH OUT FOR PERIOD	6,738,785	4,172,561	4,763,590	15,195,611	30,870,547
PAYABLES	1,755,858	1,206,540	1,775,859	6,699,816	
CHANGE	-1,465,939	-549,318	569,319	4,923,958	

MAGNEPLANE INTERNATIONAL, INC.					
FAST TRACK					
10/1/95-9/30/96	IST	2ND	3RD	4TH	TOTAL
USES OF CASH:					
CONTROLS & COMMUNICATION					
PRELIM HEAVE CONT'L MODEL					0
DEVEL'P SENSOR & COMM PLAT					0
VEHICLES					
DEV MK I MAGNET MODULES					0
DESIGN PLAT, MECH					0
ASSEMBLE TEST PLATFORM					0
ELECTRIFICATION					
DEV LSM & POWER COVERSION					0
SITE ELECTRIC DES & CONSTR					0
GUIDEWAY					
DESIGN GUIDEWAY					0
SITE & BUILD TEST TRACK					0
LINEAR VEHICLE TEST PROGRAM					0
CONTROLS & COMMUNICATIONS					
6 DOF MODEL					0
MAGNETIC FIELD ANALYSIS					0
HEAVE CONTROL MODEL					0
SWITCH MODELING					0
BLOCK CONTROLS W HANDOFF					0
ADVANCED ON-BOARD SENSORS					0
ASSEMBLE SENSOR HARDWARE					0
VEHICLE					
MARK II MAGNET BOGIE					0
H-PAD DEVELOPMENT					0
A-PAD DEVELOPMENT					0
GEAR DEVELOPMENT					0
DESIGN & FAB SHIELDING					0
UPDATE TEST PLATFORM					0
ELECTRIFICATION					0
ADD 2 BLOCK HARDW & CONTROL					0
GUIDEWAY					
MAG SWITCH DES./CONSTR					0
DESIGN & BUILD CURVE					0
ADVANCED LINEAR VEHICLE TEST	866,671	866,671	133,334		1,866,676
CONTROLS & COMM					
AERO CONTROLS DESIGN					0
INTEGRATED ATTITUDE CONT'L	91,000	91,000	21,000		203,000
FULL ON BOARD COMMUNICA					0
ROUTE MODEL	96,155				96,155
GLOBAL CONTROLS, SPEC & PRO	48,075				48,075
VEHICLE					
AERO CHARACTERIZATION					0
POWER PICK UP DESIGN					0
ON-BOARD POWER SYS					0
ON-BOARD SYSTEM DESIGN	50,000				50,000
VEHICLE FUSELAGE	2,080,000				2,080,000
VERIFY VEHICLE STRUCTURE	40,000				40,000
ASSEMBLE FULL CAP PROTO		650,000	350,000		1,000,000
ELECTRIFICATION					
ALL DYNAMIC POWER SYSTEM					0
MECHANICAL & THERMAL LSM					0
ADVANCED LSM DESIGN					0
ADVANCED LSM FAB & INSTALL	5,200,000	4,000,000			9,200,000
GUIDEWAY					
LEV PLATE THERMAL MODEL					0
BOX BEAM CONSTR METHODS					0
FULL CAPACITY TEST TRACK	17,875,000	17,875,000	8,250,000		44,000,000
VEHICLE TEST PROGRAM				1,250,002	1,250,002
TOTAL FOR PERIOD	26,346,901	23,482,671	8,754,334	1,250,002	59,833,908
CASH OUT FOR PERIOD	24,273,199	24,436,460	13,658,870	3,748,945	66,117,474
PAYABLES	8,773,518	7,819,729	2,915,193	416,251	
CHANGE	2,073,702	-953,789	-4,904,536	-2,498,943	

MAGNEPLANE INTERNATIONAL, INC.					
FAST TRACK					
10/1/96-9/30/97	IST	2ND	3RD	4TH	TOTAL
USES OF CASH:					
CONTROLS & COMMUNICATION					
PRELIM HEAVE CONT'L MODEL					0
DEVEL'P SENSOR & COMM PLAT					0
VEHICLES					
DEV MK I MAGNET MODULES					0
DESIGN PLAT, MECH					0
ASSEMBLE TEST PLATFORM					0
ELECTRIFICATION					
DEV LSM & POWER COVERSION					0
SITE ELECTRIC DES & CONSTR					0
GUIDEWAY					
DESIGN GUIDEWAY					0
SITE & BUILD TEST TRACK					0
LINEAR VEHICLE TEST PROGRAM					0
CONTROLS & COMMUNICATIONS					
6 DOF MODEL					0
MAGNETIC FIELD ANALYSIS					0
HEAVE CONTROL MODEL					0
SWITCH MODELING					0
BLOCK CONTROLS W HANDOFF					0
ADVANCED ON-BOARD SENSORS					0
ASSEMBLE SENSOR HARDWARE					0
VEHICLE					
MARK II MAGNET BOGIE					0
H-PAD DEVELOPMENT					0
A-PAD DEVELOPMENT					0
GEAR DEVELOPMENT					0
DESIGN & FAB SHIELDING					0
UPDATE TEST PLATFORM					0
ELECTRIFICATION					0
ADD 2 BLOCK HARDW & CONTROL					0
GUIDEWAY					
MAG SWITCH DES./CONSTR					0
DESIGN & BUILD CURVE					0
ADVANCED LINEAR VEHICLE TEST					0
CONTROLS & COMM					
AERO CONTROLS DESIGN					0
INTEGRATED ATTITUDE CONT'L					0
FULL ON BOARD COMMUNICA					0
ROUTE MODEL					0
GLOBAL CONTROLS, SPEC & PRO					0
VEHICLE					
AERO CHARACTERIZATION					0
POWER PICK UP DESIGN					0
ON-BOARD POWER SYS					0
ON-BOARD SYSTEM DESIGN					0
VEHICLE FUSELAGE					0
VERIFY VEHICLE STRUCTURE					0
ASSEMBLE FULL CAP PROTO					0
ELECTRIFICATION					
ALL DYNAMIC POWER SYSTEM					0
MECHANICAL & THERMAL LSM					0
ADVANCED LSM DESIGN					0
ADVANCED LSM FAB & INSTALL					0
GUIDEWAY					
LEV PLATE THERMAL MODEL					0
BOX BEAM CONSTR METHODS					0
FULL CAPACITY TEST TRACK					0
VEHICLE TEST PROGRAM	1,250,002	1,250,002	1,250,002	1,250,002	5,000,008
TOTAL FOR PERIOD	1,250,002	1,250,002	1,250,002	1,250,002	5,000,008
CASH OUT FOR PERIOD	1,250,002	1,250,002	1,250,002	1,250,002	5,000,008
PAYABLES	416,251	416,251	416,251	416,251	
CHANGE	0	0	0	0	

MAGNEPLANE INTERNATIONAL, INC.					
FAST TRACK					
10/1/97-9/30/98	IST	2ND	3RD	4TH	TOTAL
USES OF CASH:					
CONTROLS & COMMUNICATION					
PRELIM HEAVE CONT'L MODEL					0
DEVEL'P SENSOR & COMM PLAT					0
VEHICLES					
DEV MK I MAGNET MODULES					0
DESIGN PLAT, MECH					0
ASSEMBLE TEST PLATFORM					0
ELECTRIFICATION					
DEV LSM & POWER COVERSION					0
SITE ELECTRIC DES & CONSTR					0
GUIDEWAY					
DESIGN GUIDEWAY					0
SITE & BUILD TEST TRACK					0
LINEAR VEHICLE TEST PROGRAM					0
CONTROLS & COMMUNICATIONS					
6 DOF MODEL					0
MAGNETIC FIELD ANALYSIS					0
HEAVE CONTROL MODEL					0
SWITCH MODELING					0
BLOCK CONTROLS W HANDOFF					0
ADVANCED ON-BOARD SENSORS					0
ASSEMBLE SENSOR HARDWARE					0
VEHICLE					
MARK II MAGNET BOGIE					0
H-PAD DEVELOPMENT					0
A-PAD DEVELOPMENT					0
GEAR DEVELOPMENT					0
DESIGN & FAB SHIELDING					0
UPDATE TEST PLATFORM					0
ELECTRIFICATION					0
ADD 2 BLOCK HARDW & CONTROL					0
GUIDEWAY					
MAG SWITCH DES./CONSTR					0
DESIGN & BUILD CURVE					0
ADVANCED LINEAR VEHICLE TEST					0
CONTROLS & COMM					
AERO CONTROLS DESIGN					0
INTEGRATED ATTITUDE CONT'L					0
FULL ON BOARD COMMUNICA					0
ROUTE MODEL					0
GLOBAL CONTROLS, SPEC & PRO					0
VEHICLE					
AERO CHARACTERIZATION					0
POWER PICK UP DESIGN					0
ON-BOARD POWER SYS					0
ON-BOARD SYSTEM DESIGN					0
VEHICLE FUSELAGE					0
VERIFY VEHICLE STRUCTURE					0
ASSEMBLE FULL CAP PROTO					0
ELECTRIFICATION					
ALL DYNAMIC POWER SYSTEM					0
MECHANICAL & THERMAL LSM					0
ADVANCED LSM DESIGN					0
ADVANCED LSM FAB & INSTALL					0
GUIDEWAY					
LEV PLATE THERMAL MODEL					0
BOX BEAM CONSTR METHODS					0
FULL CAPACITY TEST TRACK					0
VEHICLE TEST PROGRAM	1,250,002	1,250,002	1,250,002	16,250,026	20,000,032
TOTAL FOR PERIOD	1,250,002	1,250,002	1,250,002	16,250,026	20,000,032
CASH OUT FOR PERIOD	1,250,002	1,250,002	1,250,002	11,255,018	15,005,024
PAYABLES	416,251	416,251	416,251	5,411,259	
CHANGE	0	0	0	4,995,008	

5.3.13. EXTERNAL BENEFITS

CONTENTS

5.3.13.a. INTRODUCTION

Construction of a nation-wide public transportation system constitutes the largest technology venture short of warfare. It will have an enormous impact on the gross national product and employment in the US. Foreign markets will have a major impact on the balance of trade.

More specifically, the project will employ our large body of technology workers and engineers, now idled by military spending cuts. It will keep our technical infrastructure at the cutting edge and support the development of new materials, manufacturing and construction techniques.

In addition to these obvious general benefits, Magneplane offers several specific benefits, some of which are shared by other maglev concepts.

5.3.13.b. CLEAN ENERGY

Magneplane magways require about 800 kg of aluminum per metre of magway (1,300 tons per mile). Construction of an extensive system will require a ten-fold increase in national aluminum production, and a doubling of the national electric power production. This new market for electric power, in addition to the operating power, will serve to finance the development of clean, safe nuclear power plants. This will have a major impact on the competitiveness of US industry, since we have fallen behind the rest of the world in power generating technology.

It should be noted that aluminum, unlike iron, is the most plentiful metal in the earth's crust, and is abundantly available throughout the world. It only requires electric power to reduce bauxite to metallic aluminum.

5.3.13.c. SUPERCONDUCTING TECHNOLOGY

Magneplane will support the development of a mature, practical superconducting technology and its associated support technologies. This will in turn catalyze the emergence of related technologies.

The most obvious and near-term application of superconductivity is High Gradient Separation and Filtration, which represents the only practical means for dealing with colloidal materials on a large scale. Colloidal materials are at the core of most pollution problems and most mineral beneficiation problems. Large superconducting magnetic separators and filters will be used for the following purposes:

Removal of fine particulates from waste water and storm water run-off.

Extraction of metals from oxide ores without the need for sulfide flotation, which dumps acid tailings into rivers.

Removal of phosphates and nitrates from sewage and eutrophicated marshes and ponds.

Radwaste remediation by removal of colloidal plutonium from desert soils and cooling water ponds, a problem for which the DOE has a budget of $10B/year.

A somewhat longer-term application of superconductivity is the launching of space vehicles by the use of inexpensive and highly efficient electromagnetic catapults instead of chemical rockets, which only launch less than one percent payload. The feasibility of superconducting launchers has already been demonstrated by a Darpa-sponsored research. This will restore US leadership in launch technology and the commercial space launch market.

It should be noted that the Japanese are already advertising electromagnetic space launch as a spin-off from maglev technology.

5.3.13.d. SOCIO-ECONOMIC BENEFITS

Magneplane's ability to provide high-frequency, high-speed transportation to a decentralized population will increase the mobility and flexibility of the labor force by allowing people to commute long distances without increasing the urban sprawl or the road congestion. This is already happening along the Chinkansen line in Japan, and is certain to happen along California freeways and elsewhere in the US.

Increased population mobility will relieve unemployment in areas like southern Massachusetts, northern Vermont, and central Florida, for example. It will ultimately save inner cities and control suburban sprawl by enabling "green belt zoning", as implemented in England and elsewhere in Europe. Green belt zoning laws require a belt of land around cities to remain undeveloped. This increases real estate values and investment in the inner city, at the expense of longer commuting distances and costs.

Magneplane will have as significant a world-wide demographic impact as the automobile and highway system has had. With the proper leadership from governments, Magneplane can greatly benefit society with none of the adverse consequences of the automobile.

Magneplane is unique among maglev concepts in its ability to use individual vehicles at very short headways. This enables it to provide access at a large number of malls where the infrastructure already exists. This minimizes the need for new mega-hubs with new infrastructure (parking, etc.), and also makes it possible to serve high-priority freight requirements. Magneplane can go where people and goods (including solid waste) actually originate and terminate.

INDEX

to the System Concept Definition Report, volumes 1-5

System Concept Definition Report for the National Maglev Institute - Volume 5, Magneplane International, Inc, 1992 -