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National Maglev Initiative
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16. Abstract

The physical and operational characteristics of four existing and planned maglev systems were surveyed pertinent to the intermodal interface for each system. The maglev systems investigated were: Grumman "New York State" (Configuration 002) Maglev; Transrapid Intercity (Transrapid 07) Maglev; HSST Passive Intermediate Speed (HSST-300) Maglev; and Japan Railways Vertical Magnet (Configuration MLU 002) Maglev. The focus of this study was to investigate the feasibility of using existing railroad right-of-way to access center-city terminals in one of three possible methods: Maglev vehicles traveling over existing railroad tracks with the use of steel guide wheels and some means of exterior propulsion; maglev vehicles transferred onto modified railroad flatcars and transported over existing railroad tracks with locomotive power; or new grade-separated maglev guideways on existing railroad rights-of-way. AREA clearance requirements were compared with those used by Amtrak for unrestricted operation on its nationwide system, with the finding that Amtrak clearance requirements were the most restrictive. Each of the four maglev technologies were superimposed upon the Eastern U.S. Summary Clearance Diagram in two different modes of transportation -- the "piggyback" and the "at-grade" modes and their impacts upon the clearance diagram were evaluated. As the result of this evaluation, the HSST-300 maglev technology was carried forward for the investigation of a maglev-rail car carrier intermodal concept. This investigation showed that a transition process is technically feasible and can be achieved within a four-to-five minute time span with little or no passenger disruption. To assess the feasibility of maglev systems accessing existing center city terminals in the United States, information on 15 selected cities was reviewed, and the feasibility of implementing maglev systems in these areas was assessed. Recommendations are presented for each urban area.

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in.) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectares (he) = 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x - 32) (5/9)] °F = y°C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (kn^2) = 0.4 square mile (sq mi, mi^2)
1 hectare (he) = 10,000 square meters (m^2) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH-CENTIMETER LENGTH CONVERSION

INCHES: 0 1 2 3 4 5 6 7 8 9 10

CENTIMETERS: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

25.40

QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NBS Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10286.

PROJECT BAA-206
MAGLEV/RAIL INTERMODAL EQUIPMENT AND SUSPENSION STUDY
FINAL REPORT

EXECUTIVE SUMMARY

The PB Team surveyed the physical and operational characteristics of four existing and planned maglev systems pertinent to the intermodal interface for each system. The maglev systems investigated include:

- Grumman "New York State" (Configuration 002) Maglev
- Transrapid Intercity (Transrapid 07) Maglev
- HSST Passive Intermediate Speed (HSST-300) Maglev
- Japan Railways Vertical Magnet (Configuration MLU 002) Maglev

These systems characteristics were evaluated and addressed such issues as:

- Type of levitation
- Guideway requirements for carrier entry, levitation and propulsion (This information would be used to evaluate the feasibility of transporting maglev vehicles in some fashion over existing railroad tracks, i.e., in a "piggy-back" mode.)
- Vehicle dimensions
- Limiting route alignment
- Loaded vehicle weight
- Height of door sill, door configuration
- Maximum train length
- Method of coupling

- Operational characteristics at slow speed
- Supporting structure when not levitated
- Levitation power requirements and sources
- Auxiliary power requirements and sources
- Vehicle dynamics stationary on carrier

A matrix displaying this information was prepared for each maglev system.

If these maglev systems are to be commercially and economically viable, they will have to access the centers of major metropolitan areas. The focus of this study was to investigate the feasibility of using existing railroad rights-of-way to access center-city terminals, in one of three possible methods:

- maglev vehicles travel over existing railroad tracks with the use of steel guide wheels and some means of exterior propulsion (e.g. locomotive power.) A modification of this alternative would be to construct a "dual-mode" (or "at-grade") guideway, essentially a maglev guideway outfitted with standard rails at gauge;
- maglev vehicles are transferred onto modified railroad flatcars and transported over existing railroad tracks with locomotive power; or
- new grade-separated maglev guideways would be constructed on existing railroad rights-of-way, either in an exclusive or shared right-of-way configuration.

As a result of using existing railroad corridors, certain mandated horizontal and vertical clearance requirements must be met. AREA clearance requirements were compared with those used by Amtrak for unrestricted operation on its nationwide system, with the finding that Amtrak clearance requirements were the most restrictive. This information was used to prepare a total of three summary clearance diagrams for maglev equipment. Because the Eastern U.S. Summary Clearance Diagram more correctly addresses the high platform station configuration, and high platforms are assumed for maglev operations (low platforms would necessitate a longer station dwell time), this diagram was used to assess the compatibility of present and planned maglev technologies with existing railroad infrastructure around the country.

Each of the four maglev technologies were superimposed upon the Eastern U.S. Summary Clearance Diagram in two different modes of transportation - the "piggyback" and the "at-grade" modes. Their impacts upon the clearance diagram were evaluated, and advantages and disadvantages of each transportation mode were discussed.

The results of this preliminary feasibility analysis for the four maglev technologies and the two transportation modes were summarized with the finding that both the JR MLU 002 and the HSST-300 systems fit within the required clearance diagram. Both the HSST-300 and JR MLU 002 maglevs appear to be feasible in the "piggyback" mode, but only the JR MLU 002 might possibly work in the "at-grade" mode. The JR design has the significant advantage of being able, with minor modification, to run on existing rails on its own or to be accommodated on board a rail car carrier, but its development is at least ten years away and very little information was available during the course of the study on which to base meaningful conclusions.

At this time, the required clearance envelope for unrestricted operation on existing railroad corridors in the United States precludes use of the Grumman and Transrapid maglev systems in either the at-grade or piggyback modes due to their excessive width and wrap-around body designs. However, further investigation of individual corridors in the United States could identify facility and/or operational modifications that would permit use of these wider technologies to gain access to center city terminals.

As a result of the above discussion, the HSST-300 maglev technology was carried forward in this study for the investigation of a maglev-rail car carrier intermodal concept.

The maglev-rail car carrier intermodal concept would allow the selected HSST-300 maglev to transition from the high-speed maglev guideway to a modified rail car carrier for transport over existing corridors into center city terminals. Obviously, this transition location would be as close as possible to the terminal to minimize the travel time in the "piggyback" mode. This investigation showed that this transition process is technically feasible and can be achieved within a four-to-five minute time span with little or no passenger disruption. However, if this intermodal concept is furthered as a means of accelerating maglev implementation in the U.S., much more work would be necessary.

To assess the feasibility of maglev systems accessing existing center city terminals in the United States, information on 15 selected cities was reviewed. These cities anchor major metropolitan areas in some of the most heavily travelled transportation corridors on the west coast, midwest and east coast, and were thought to be good candidates for some type of high speed guided ground transportation in the future. This information was further bolstered by telephone conversations with appropriate Federal, State and local officials, where special attention was paid to:

- the presence and location of existing transportation terminals and their effectiveness in serving the needs of the individual metropolitan area;
- the physical characteristics of the transportation corridors which serve those terminals;
- characteristics of adjacent land uses, and any proposed modifications;
- plans for major capital investment in transportation facilities (e.g., transit systems, multimodal facilities, major rehabilitation, etc.);
- restrictive horizontal and vertical clearances;
- horizontal curve radii;
- length and height of existing station platforms and the presence of platform gaps;

- characterstics of current operating equipment;

- presence of electrification and power pickup arrangements, if applicable; and

- present and future interfaces with other transportation modes.

At the same time, certain operational characteristics such as terminal and line ownership, existing traffic levels, timetables and other factors were evaluated as that information was made available.

The individual urban areas were described in terms of their existing transportation infrastructure and future transportation plans and the feasibility of implementing maglev systems in these areas was assessed. In assessing these individual urban areas, certain assumptions regarding the viability of certain corridors which access the central business districts were made. Much of the proposed corridor discussion assumes the shared use of existing railroad right-of-way, an important component of any future high speed transportation network. (A recent Martin Marietta study estimates that shared railroad right-of-way could represent about 77% of any future maglev system's route length required to penetrate center cities, as compared to about 17% for shared highway right-of-way.) Any proposed alignments that are addressed assumes acceptance of this shared right-of-way concept, and have not been discussed with the asset owners, adjacent land owners, city residents, environmental groups or appointed/ elected officials in the individual urban areas. Following are recommendations for those individual urban areas.

7.2 Recommendations

San Francisco

The existing CalTrain terminal at 4th and Townsend Streets does not serve the central business district (CBD) well, as it is geographically distant and has limited intermodal capability. This deficiency is being addressed in the study for a possible new terminal, but the construction cost estimate for either of the three alternatives may delay implementation of this worthwhile project. In an associated matter, the planned alignment for this terminal relocation project would severely constrain speeds into and out of the CBD. Should the proposed terminal project be delayed, an alternative location for a terminal station could be at the San Francisco International Airport.

The CalTrain corridor to San Jose is well suited, for the most part, for higher speed operation. Numerous grade crossings would require separation and some curve smoothing would be desirable.

Los Angeles

Los Angeles Union Passenger Terminal (LAUPT) is centrally located in downtown Los Angeles and is fast becoming a true intermodal terminal. As such, it deserves further consideration as a future high speed transportation terminal. The access into and out of LAUPT is rather circuitous and would have to be improved for a future high speed (HS) system One question to be addressed in the near future will be LAUPT's ability to absorb future HS activity along with its present and proposed operations. The Southern Pacific Transportation Company (SPTC) San Fernando corridor appears to be rather well suited for higher speed operation, but has numerous grade crossings that would require separation in some fashion.

San Diego

The old Santa Fe Depot is well located within downtown San Diego, and is also becoming a true intermodal terminal. The railroad corridor which accesses the terminal from the north is constrained by existing land use and topographical features, consequently speeds would have to be adjusted accordingly. North of State Highway 52, the Interstate 5 alignment should be followed until the railroad corridor once again parallels Interstate 5.

St. Louis

The city appears to be furthering a planned intermodal facility just west of Union Station, however, a re-examination of the Union Station site should be made. The old terminal has undergone a dramatic renovation and has a tremendous unused capacity for additional transportation infrastructure. Using Union Station as the future intermodal terminal would also negate the need for an additional Metro Link station at Jefferson Avenue. If possible, the existing MacArthur Bridge should be used to cross the Mississippi River.

Chicago

Chicago Union Station (CUS) appears to be a natural choice for a future maglev terminal. There are no major physical restrictions, an extensive station renovation is being completed and the proposed Central Area Circulator project would provide easier interface with other activity centers and transportation modes. The SPTC/Amtrak/Santa Fe corridor which parallels the DesPlaines River appears to be well suited for higher speed technology. One area requiring further study would be the corridor's intersection with Conrail/Norfolk Southern (NS) trackage just south of the Chicago River. CUS' ability to absorb additional transportation operations would also require study.

Cleveland

The existing infrastructure and ambitious plans for Tower City Terminal make the terminal the restored focal point for intermodal transportation in Cleveland. The railroad alignments necessary for access to the terminal are more circuitous and will require extensive speed restriction. One primary focus of future study should be the improvement of these corridors for higher speed operation.

Buffalo

The existing Exchange Street Station is in a prime location to serve as a future maglev terminal. Its intermodal transportation capability is well documented, however, run-through flexibility should be improved. This improvement may be possible west of the station by constructing a southbound connection to the existing lakefront trackage which parallels State Highway 5.

Rochester

The existing intercity rail terminal in Rochester is in a fair location and could serve as a future maglev terminal. However, the trackage accessing the terminal from both the east and west has some constraining curvature and should be straightened if at all possible. Additional investigation into alternative terminal locations should occur at some future time.

Syracuse

Officials in Syracuse have recognized the inability of their existing rail terminal to serve as a future intermodal terminal and have initiated studies for a new site. However, there are some reservations about the location of the proposed Park Street site with respect to its proximity to downtown and Syracuse University. The possibility of sharing the Interstate 690 right-of-way north of downtown and reusing the old New York Central terminal should be re-examined.

Albany

It would be possible to have the maglev terminal in Rensselaer, which has adequate bus and taxi connections into the greater Albany area. However, other locations for an intermodal terminal are being discussed and it is too soon to tell if any of these garner support. Another issue which will impact the decision is the proposal to link a future intermodal terminal in Rensselaer with an extensive Riverfront development. For the most part, the corridor running through Albany / Rensselaer is suitable for higher speed operation.

New York City

Penn Station is the intermodal terminal facility in New York City and is undergoing an extensive improvement project. However, there are some problems in using this terminal as a future maglev station. First, the tunnels under the Hudson and East Rivers are very narrow and would not allow wider equipment without modification. Second, Penn Station suffers today from the lack of operational capacity. Lastly, trains accessing Penn Station from the north must travel the Westside Connection which includes a very constrained curvature as it approaches the station. All of these issues must be addressed adequately before Penn Station could be used as a future maglev station. If maglev access into Penn Station is not possible for some reason, an alternative transfer station outside the city would have to be evaluated.

Pittsburgh

Penn Station is centrally located and could serve as a future maglev station. However, the hilly topography of the metropolitan area creates a difficult climate for high speed operation. Curves are tight and grades are steep and maglev (or other high speed technology) would have to overcome these with expensive structures and bridges.

Philadelphia

The 30th Street Station is ideally situated for use as a future maglev terminal. It is truly an intermodal facility and appears to have adequate capacity for additional transportation infrastructure. Obviously, the Northeast Corridor is perhaps the best corridor in the nation for further high speed improvements.

Boston

The intermodality and commercial activity present at the South Station Transportation Center, coupled with on-going improvements on the New Haven to Boston corridor, makes this an ideal location for a future maglev terminal.

Washington, D.C.

The unique mix of transportation modes, commercial activity and the relatively high speed Northeast Corridor makes Union Station the likely candidate for a future maglev terminal in Washington, D.C.

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1.0 INTRODUCTION

In September 1990, the U.S. Departments of Energy and Transportation and the Army Corps of Engineers issued Broad Agency Announcement (BAA) 90-1 soliciting abstracts for the study of a wide variety of subjects related to magnetically levitated (maglev) transportation.

In response to this solicitation on October 5, 1990, Parsons Brinckerhoff Quade & Douglas, Inc. submitted an abstract proposing the study of a method of transporting maglev trains from the perimeters of densely populated urban areas to their central business districts (CBD) over existing railroad facilities using modified flatbed rail cars.

In November 1990, Parsons Brinckerhoff was notified that its abstract had been selected for further study from over 200 received and in March, 1991, the firm was notified that its proposal had been selected as one of 27 for negotiation of a contract. Following that negotiation, Parsons Brinckerhoff was awarded a contract on July 12, 1991 to commence with the study, which was to be completed in December 1992. (A contract modification extends the study schedule to February 1993.)

1.1 Purpose of Study

This study is based upon a hypothesis in which maglev vehicles are transferred onto specially designed railroad flatcars to provide maglev access to the CBD's of major metropolitan areas. At the same time, the study evaluates existing railroad infrastructure, particularly, selected center city terminals and the corridors which access them.

Magnetically levitated vehicles are proposed to provide high speed surface transportation between major urban centers in the U.S. One of the major challenges for such systems is right-of-way access to the urban center traditionally served by rail. The traditional approach to urban access has been to construct new, grade separated guideways and terminals to accommodate a new system. However, in today's metropolitan centers, the cost of such an approach may be prohibitive.

1.1.1 Solution Concept

This study analyzes new concepts for accessing major center-city passenger terminals by means of existing railroad infrastructure in an effort to maximize comfort, convenience and speed for the users of the system, to make maglev accessible for terminal operations, maintenance and deliveries, and to minimize cost and disruption to the urban community.

1.1.2 Project Objectives

The objectives of the study are:

- To determine the access limitations to major urban inter-city public transportation terminals;
- To determine the physical and technological feasibility of the maglev/rail intermodal transfer vehicle concept;
- To provide a conceptual layout, design and feasibility analysis for one selected typical passenger terminal intermodal interface served by one selected typical inter-city maglev; and
- To evaluate selected center-city terminals and the corridors that access them, and determine the feasibility of implementing maglev systems on this existing infrastructure.

1.2 Study Structure and Schedule

Densely populated urban areas separated by a distance of up to 805 km (500 miles) are recognized as a potential market for maglev. This study addresses access to public transportation terminals in cities included in the following corridors:

- San Francisco, Los Angeles, San Diego
- St. Louis, Chicago, Detroit
- Detroit, Cleveland, Buffalo, Rochester, Syracuse, Albany, New York City
- Cincinnati, Pittsburgh, Philadelphia
- Boston, New York City, Philadelphia, and Washington.

1.2.1 Approach

Chapter 2 discusses the physical and operational characteristics of four existing or proposed maglev systems pertinent to the intermodal interface for each system. The study identifies in Chapter 3 the limiting characteristics of a maglev vehicle that can negotiate the approaches to the urban terminals on board the rail car carrier. The possibility of constructing "dual-mode" guideway that would accommodate both maglev vehicles and railroad equipment on the same guideway is addressed in Chapter 4. (This "dual-mode" guideway concept was investigated by Thyssen Henschel for the Federal Railroad of Germany (Deutsche Bundesbahn) in 1987. Thyssen Henschel believed the "dual-mode" guideway was technically feasible and would add a premium of about 45 percent to the cost of constructing a normal guideway for magnetic levitated trains.) The feasibility of operating both the piggyback and dual-mode (or "at-grade) concepts over existing railroad corridors is tested in Chapter 4, particularly with respect to required clearances on those corridors.

The concept of transferring maglev vehicles onto modified railroad flatcars and transporting them over existing railroad tracks with locomotive power (i.e., in "piggyback" fashion) is addressed in Chapter 5 of this report. A description of the fifteen (15) selected cities follows in Chapter 6. The existing railroad terminals and corridors are evaluated with respect to future maglev operation, particularly with regard to their possibility for intermodality and physical restrictions such as bridge / tunnel cross-sections, platform heights and lengths and restrictive alignments. Conclusions and recommendations are presented in Chapter 7.

1.2.2 Program Limits

This study is limited to addressing those issues directly related to demonstrating the feasibility of the maglev/rail intermodal interface concept, and its physical implementation in selected United States cities.

1.2.3 End Products

The end product of this study is to be a one volume final report which encompasses the findings of three interim volumes. The individual volumes summarize various aspects of the study as follows:

Volume 1 describes the restrictions to gaining access to the existing urban transportation terminals and the characteristics of several existing or proposed maglev designs. Based on these findings, the report further describes the available clearance envelope for a Maglev / carrier for each of the maglev designs considered in combination with each characteristic urban access route. For systems where the available envelope is too small, qualitative judgments are provided addressing the cost effectiveness of eliminating the interferences.

Volume 2 describes a complete transfer scenario for a selected configuration. Included in the discussion is the basis for choosing the rail carrier configuration and qualitatively how the other maglev designs considered would be handled. The report includes layout drawings and the general strength, power and braking, and performance requirements for the rail carrier configuration chosen.

Volume 3 summarizes the results of the study presented in the first two volumes, further evaluates the characteristics of center city transportation terminals and their associated corridors and assesses the feasibility of implementing maglev systems in these urban centers.

2.0 MAGLEV SYSTEM CHARACTERISTICS

The PB Team surveyed the characteristics of four (4) existing and proposed maglev systems and produced a matrix that compared those physical and operational characteristics pertinent to the intermodal interface for each system. The maglev systems investigated include:

- Grumman "New York State" (Configuration 002) Maglev - This maglev design, proposed by the Grumman Corporation for the initial New York State Maglev evaluation, uses electrodynamic suspension (EDS) with linear synchronous motor (LSM) propulsion.

- Transrapid Intercity (Transrapid 07) Maglev - The most advanced maglev system built to date, this system is ready for commercial application and uses electromagnetic (EMS) technology.

- HSST Passive Intermediate Speed (HSST-300) Maglev - Still in the early stages of development, this EMS maglev system was selected because it is a higher speed version of earlier prototype models and has been proposed for use in Nevada and other locations.

- Japan Railways Vertical Magnet (Configuration MLU 002) Maglev - This system was built as a test vehicle using EDS technology. The prototype vehicle was destroyed in an October 1991 fire. Designers are presently developing the next-generation system, but full commercial development is perhaps 10 years away. Before the fire, this system represented the best developed EDS technology.

The physical and operational characteristics of these systems were evaluated and the following issues were addressed:

- Type of levitation
- Guideway requirements for carrier entry, levitation and propulsion (This information was used to evaluate the feasibility of transporting maglev vehicles in some fashion over existing railroad tracks, i.e., in a "piggy-back" mode.)
- Vehicle dimensions
- Limiting route alignment

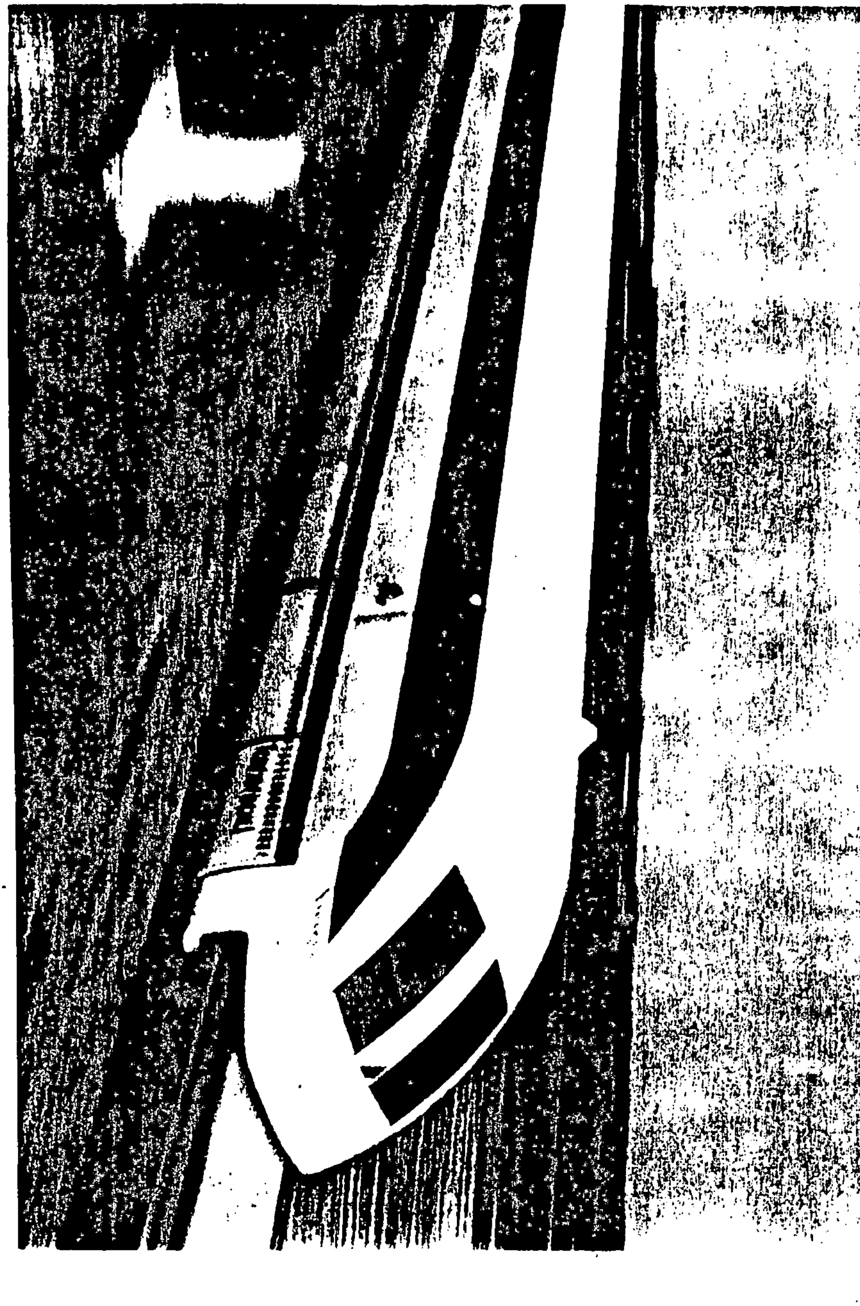
- Loaded vehicle weight
- Height of door sill, door configuration
- Maximum train length
- Method of coupling
- Operational characteristics at slow speed
- Supporting structure when not levitated
- Levitation power requirements and sources
- Auxiliary power requirements and sources
- Vehicle dynamics stationary on carrier

2.1 Grumman "New York State" (Configuration 002) Maglev

Earlier developments, Configurations 001 and 002, were based on electrodynamic suspension (EDS) technology. As part of their System Concept Definition (SCD) contract, Grumman has started developing a new system based on superconducting electromagnetic suspension (EMS). Based upon discussions with Grumman representatives in October 1991, it was decided to include this newer development in this study. (Further refinements in this proposed system show differences between the final Grumman SCD concept and this report. However, to avoid unproductive efforts in trying to "hit a moving target," the system characteristics as presented in this report were not revised.) This new system is still in the conceptual design stage. No test car has been built and several vehicle parameters are yet to be finalized.

2.2 Transrapid Intercity (Transrapid 07) Maglev

The German Transrapid 07 is the most advanced maglev built and is shown on Figure 2-1. This model was selected for this study because of its 500 kph (311 mph) design speed that is considered to be favorable for intercity transportation. Transrapid 07 is ready for commercial application and has been tested in a continual near-service operation at 435 kph (270 mph) sustained speed on its test track at Emsland, Germany. The maximum bending angle between adjoining sections is about 3 degrees (which corresponds to a horizontal curve with an approximate radius of 1030 meters or 3,380 feet) and may not be sufficient to negotiate tight curves or narrow reverse curves common in existing railroad corridors and passenger terminal areas.



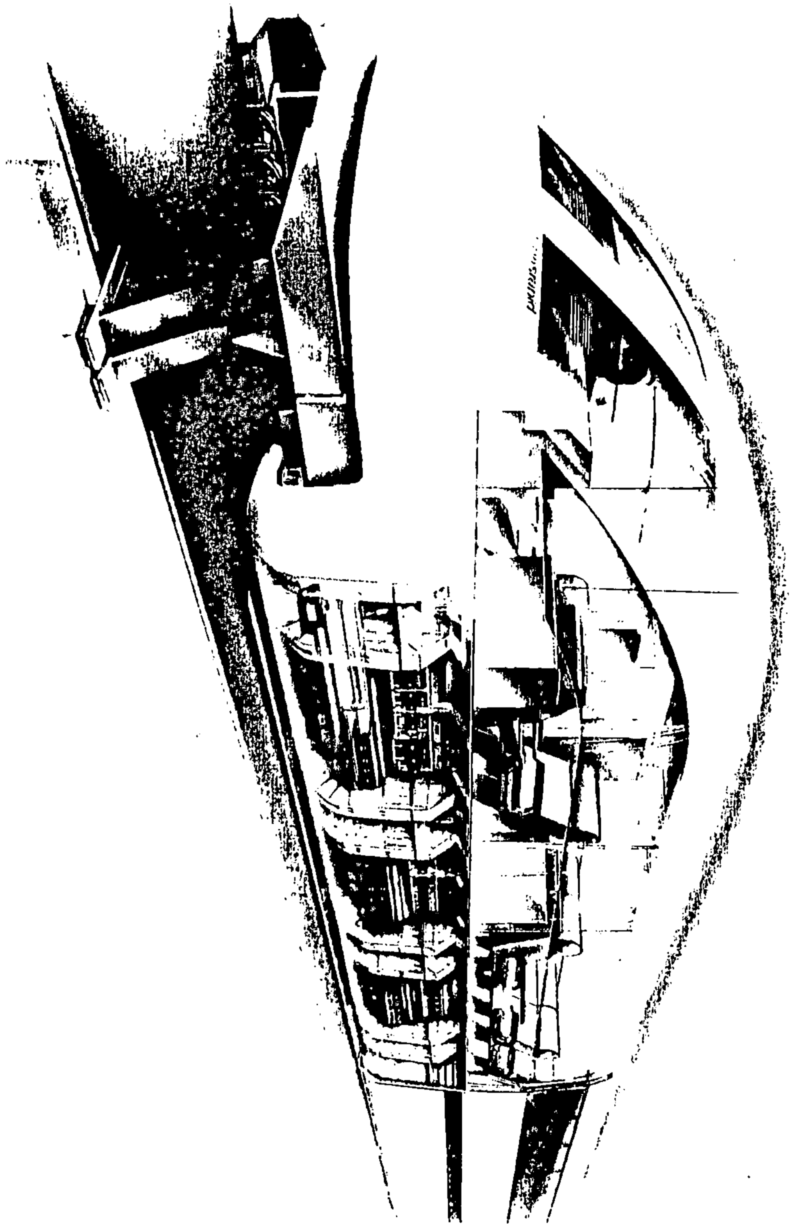


FIGURE 2-1

2.3 HSST Passive Intermediate Speed (HSST-300) Maglev

The HSST-300 configuration maglev technology has a proposed maximum speed of 330 kph (205 mph), and is proposed as an intercity mode of transportation by the builder. (See Figures 2-2 and 2-3.) HSST-300 technology is based upon earlier prototype models, HSST 100 and HSST 200. Three prototype cars of HSST 200 have been built and run at lower speeds. No high speed runs, other than the small unmanned HSST-01, have been made, but the builder has planned high speed testing on the proposed Las Vegas project. HSST-300 is in the early stages of development.

2.4 Japan Railways Vertical Magnet (Configuration MLU 002) maglev

The MLU 002 was built as a test vehicle by the Japanese using electrodynamic suspension (EDS) technology (see Figure 2-4). This vehicle uses superconducting magnets requiring a cryogenic cooling system. The latest development (MLU OOX 1), is described as the proposed commercial application in this study. The MLU 00X 1 also utilizes EDS technology, but its shape and overall cross-sectional dimensions are constantly evolving. One reason for these changes is that the Japanese are anticipating much of their transportation to be underground. An optimum shape and resulting reduced overall dimensions will probably lead to less tunnelling costs and reduced air drag. The magnetic suspension bogies are located at the ends between the vehicles. The final JR maglev design is still considered to be undefined. Full development is not expected to be achieved for at least ten years, and was set back somewhat by a vehicle fire in October 1991 that destroyed the MLU 002 vehicle. Designers are presently working on a new vehicle (Configuration MLU OOX 1). Little information on their schedule is available at this time.

The system characteristics for all four systems are summarized in Table 2-1.

TABLE 2-1

	Grumman NY State Maglev (Configuration 002)	Transrapid 07	HSST Passive Intermediate Speed (HSST – 300)	JR Vertical Magnet Maglev (MLU 002)
Type of Levitation	Attractive Magnet (EMS)	Attractive Magnet (EMS)	Attractive magnet (electromagnetic suspension – EMS)	Repulsive (electrodynamic suspension – EDS)
Maximum Test Speed	Not Tested	436 km/hr (270 mph)	Not Tested – 330 km/hr. (205 mph) – projected	500 km/hr. (312 mph)
Service Speed	500 km/hr. (312 mph) projected	300–500 km/hr. (186 – 312 mph)	300 km/hr. (186 mph) estimated	550 km/hr. (342 mph)
Air Gap	10 mm (0.39 in.)	10 mm (0.39 in)	11 mm (0.43 in)	100 mm (3.9 in.)
Propulsion Located in:		Guideway (long stator)	Vehicle (short stator)	Guideway (long stator)
Guideway Width	Double track – 11.0 m (36.1 ft.) Single track – Unknown	Double track – 8.53 m (28.0 ft.) Single track – 2.8 m (9.2 ft.)	Double track – 9.1 m (30.0 ft.) Single Track – 4.3m (14.11 ft.)	Double track – 12.7 m (41.7 ft.) Single track – 4.3 m (14.1 ft.) approximately
Vehicle Dimensions	End Car / Mid Car	End Car / Mid Car	End Car / Mid Car	End Car / Mid Car
Length	18 m (59.0 ft.) / 12 m (39.4 ft.)	26.99 m (88.5 ft.) / 24.77 m (81.3 ft.)	22.0 m (72.18 ft.) / 20.0 m (65.62 ft.)	27.5 m (90.2 ft.) / 21.6 m (70.9 ft.)
Width	3.66 m (12.0 ft.)	3.7 m (12.1 ft.)	3.2 m (10.50 ft.)	2.9 m (9.5 ft.)
Height	3.92 m (12.9 ft.)	4.06 m (13.3 ft.)	3.2 m (10.50 ft.)	3.3 m (10.8 ft.)
Maximum Train Length	TBD	up to 10 vehicles – 252.14 m (827.2 ft.)	6 vehicle basic configuration – 126.6 m (415 ft.)	6 – 14 vehicles (141–315.2 m)
Vehicle Capacity:	End Car / Mid Car	End Car / Mid Car	End Car / Mid Car	End Car / Mid Car
No. of passengers/seats	50 / 50	78/40 / 113/56	90/90 / 100/100	TBD / TBD
Individual Vehicle Weight				
DL	23.2 M.T. (51,156 lbs.) / Included in end car	45.0 M.T. (99,225 lbs.) / 45 M.T. (99,225 lbs.)	23 M.T. (50,716 lbs.) / 22 M.T. (48,510 lbs.)	TBD / TBD
LL	8.9 M.T. (19,625 lbs.)	10 M.T. (22,000 lbs.) / 13 M.T. (28,600 lbs.)	7 M.T. (15,424 lbs.) / 7.8 M.T. (17,138 lbs.)	TBD / TBD
Total	32.1 M.T. (70,781 lbs.)	55 M.T.(121,225 lbs.) / 58 M.T. (127,825 lbs.)	30 M.T. (66,139 lbs.) / 29.8 M.T.(65,648 lbs.)	30 M.T. (66,150 lbs.) / 20 M.T. (44,100 lbs.)
Route Alignment Limitations				
Min. Horizontal Radius	500 m (1640 ft.)	500m (1640 ft.), 4180 m (13.741 ft.) @ 400 km/hr.,6530 m (21,424 ft.) @ 500 km/hr.	250 m (820 ft.), 2500 m (8200 ft.) @300 km/hr (186 mph)	(Minimum radius unknown) 8000 m (26,248 ft.) @ 483 km/hr. (300 mph)
Min. Vertical Radius (sag)	TBD	19,290 m (63,287 ft.) @ 500 km/hr.	3000 m (9842 ft.)	TBD
(crest)	TBD	38,580 m (126,573 ft.) @ 500 km/hr.		TBD
Max. Grade	3.5% @ 483 km/hr (300 mph) 10% allowable at reduced speeds	3.5% (suggested), 10% (allowable)	6% (estimated)	4%
Guideway Requirements for:				
Vehicle Support	Trapezoidal Inverted V–shaped Guideway	Inverted A–shaped concrete or steel girder (Tight fabrication and construction tolerances required)	Double Beam Type Prestressed Concrete Guideway (Tight fabrication and construction tolerances required)	Trough–Type Guideway
Levitation	Iron rail attached to underside of beam	Long Stator w/Armature Winding attached to underside of guideway	Inverted U–shaped iron section	Levitation and guidance coils incorporated in prestressed concrete guideway
Propulsion	TBD	Long Stator w/Armature Winding attached to underside of guideway	2–0.25 m (10") wide aluminum reaction plates	Propulsion coils incorporated in prestressed concrete guideway
Carrier Entry:	Brought onto rail car carrier powered at walking speed	Tight guideway tolerances may prevent installation of long stator on rail car, vehicle to be pushed or pulled onto carrier unpowered.	Brought onto rail car carrier powered at walking speed.	Parapets eliminated. Vehicle to be pushed or pulled onto carrier unpowered usin retractable wheels.
Height of Door Sill/ Door Configuration	1.72 m (5.64 ft.), door size – 0.76 m x 2.05 m (2.5 ft. x 6.7 ft.) Two slide doors/side, (4 per vehicle)	Door sill is 2.26 m (7.42 ft.) from car roof Door height is 2.00 m (6.6 ft.)	Door Height – 1.91 m (6.27 ft.), Door Sill – 2.11 m (6.92 ft.) from roof Two slide doors/side/car (4 per car)	TBD. Probably at top of guideway.
Method of Coupling	TBD	Total coupling is 0.25 m (10") long, maximum bend is 3 degrees (not designed to follow reverse curves)	Rod–type links (End cars can have automatic couplers)	Coupling mechanism located on suspension bogies.
Operational Characteristics at Slow Speed	TBD, Levitation is independent of speed	Levitation is independent of speed. Electric Battery Powered (15 min. duration)	Levitation is independent of speed 280 v storage battery	Retractable Wheels Required below 100 km/hr. (62 mph) – 4 wheels/vehicle. Cryogenic Helium Necessary for Levitation
Supporting Structure When Not Levitated	Vehicles operate on skids	Up to 16 skids per vehicle rest on gliding plane located on top of guideway	Vehicles operate on skids located near levitation magnets (20 skids/vehicle)	Retractable Wheels support vehicle on gliding plane.
Levitation Power Requirements and Sources	TBD	Linear Synchronous Motor (LSM), 103 kw for levitation, guidance, train control, communication and lighting	Single–sided Linear Induction Motor (LIM) – 3000 VDC, 1.1 kw/M.T. of vehicle weight	Linear Synchronous Motor (LSM) (Battery powered operation to 120 km/hr. (75 m
Auxiliary Power Requirements and Sources	TBD	60 kw for Air Conditioning, 25 kw to recharge batteries, 60 kw for heating	1.0 kw/M.T. of vehicle weight for air conditioning, lighting, train control, etc.	100 kw/vehicle (primarily for cooling)
Vehicle Dynamics Stationary on Carrier	TBD	TBD	Unknown	TBD
Braking				
Primary Secondary	TBD	Phase – Reversing (generating) Linear Motor Brake Magnetic drag (above 31 mph), composition landing skids (<31 mph)	Phase–Reversing (Generating) Linear Motor Brake Automatic Hydraulic Mechanical Brake	Phase – reversing (Generating) Linear Motor Brake Skids
Energy Requirements (BTU/seat–mile)	850 @ 483 km/hr (300 mph) projected	300 @ 300 km/hr. (186 mph), 500 @ 418 km/hr. (260 mph)	275 @ 300 km/hr (186 mph)	840 @ 418 km/hr. (260 mph)

CUTOUT VIEW of HSST-300

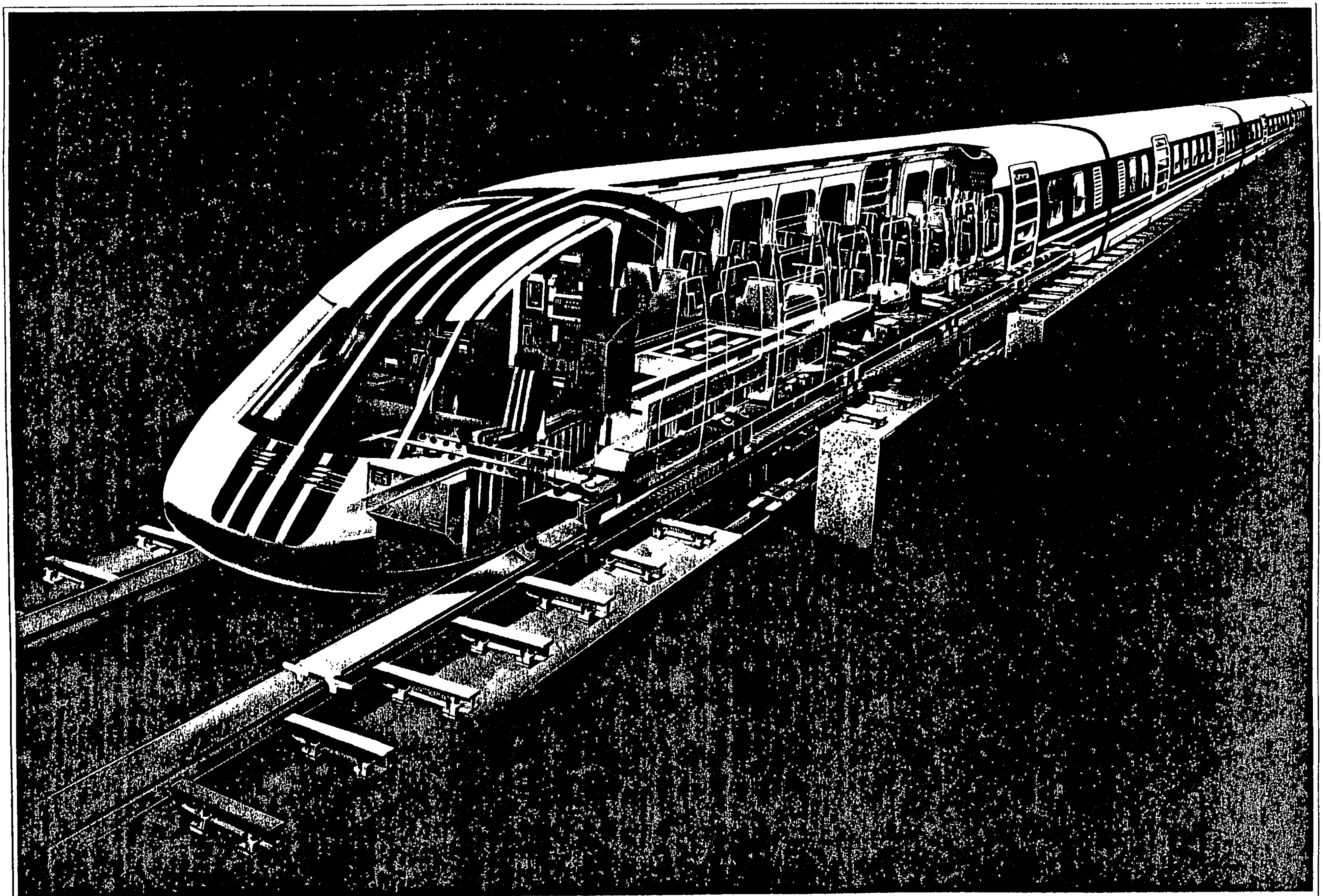


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FIGURE 2-2

HSST-300 BASIC CONCEPT

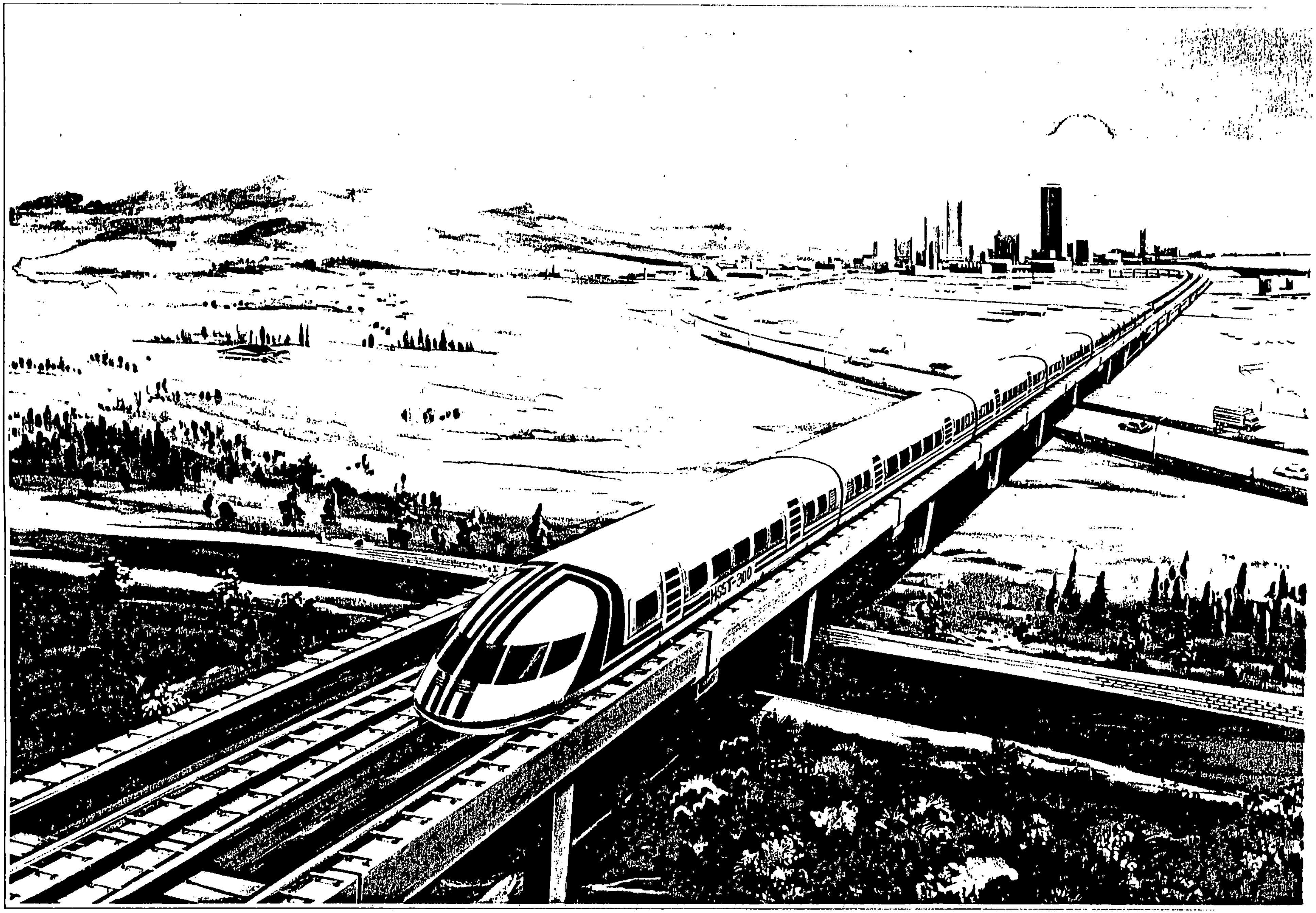

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FIGURE 2-3

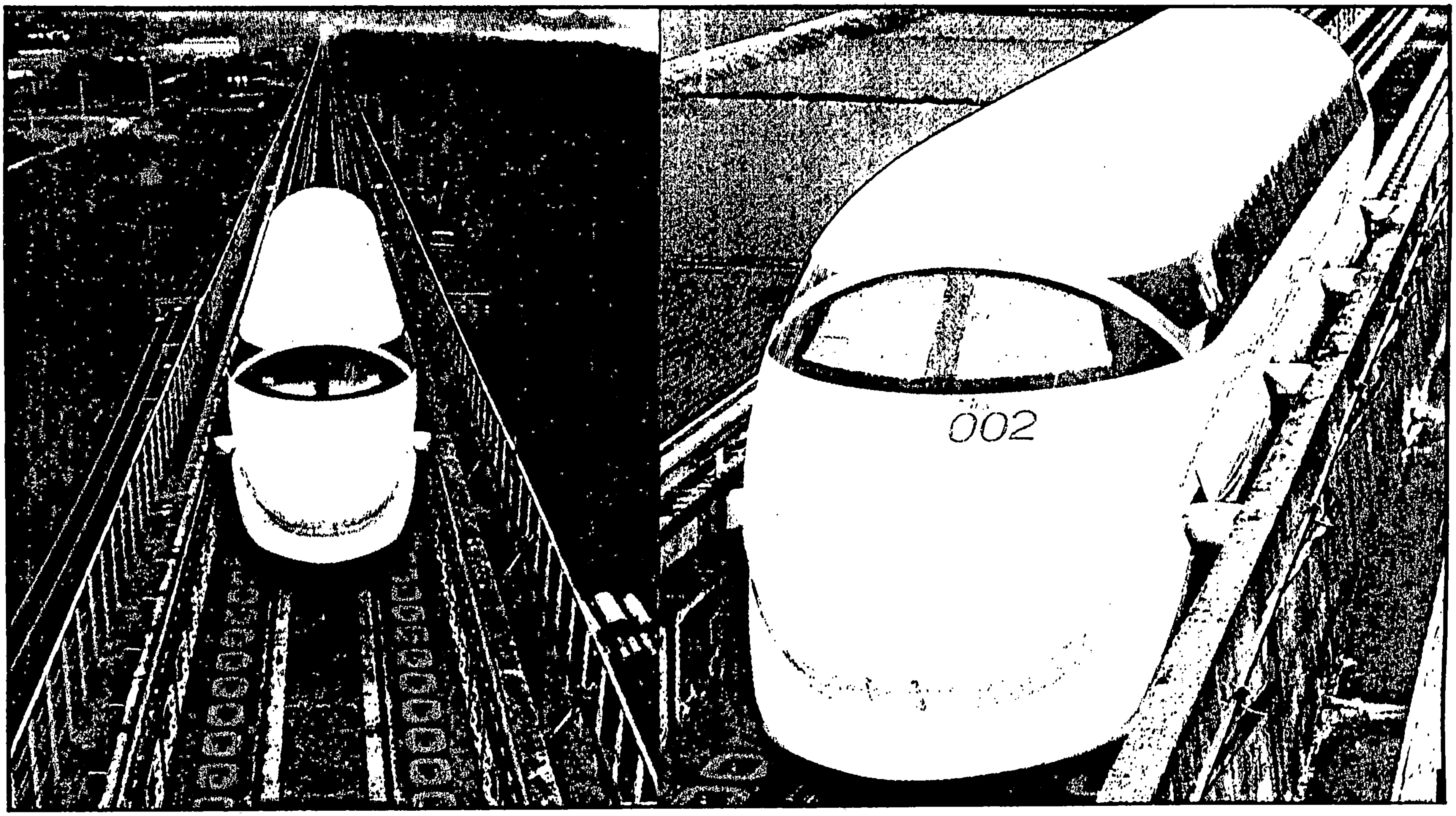


FIGURE 2-4

3.0 ACCESS TO THE CENTER CITY

If maglev systems are to be commercially and economically viable, they will have to access the centers of major metropolitan areas. The traditional approach to urban access has been to construct new, grade separated guideways and terminals on newly acquired right-of-way. In today's urban centers, such an approach can be extremely costly, disruptive and time-consuming. This study focuses on the feasibility of using existing railroad rights-of-way as a means of accessing center-city terminals.

If maglev systems are to access the nation's center cities over existing railroad corridors, it can be accomplished in one of three possible methods:

- Maglev vehicles travel over existing railroad tracks with the use of steel guide wheels and some means of exterior propulsion (e.g. locomotive power). A modification of this alternative would be to construct a "dual-mode" guideway, essentially a maglev guideway outfitted with standard rails at gauge. Such a "dual mode" guideway might allow maglev vehicles to transport themselves into rail passenger terminals while leaving existing railroad facilities relatively intact.

- Maglev vehicles are transferred onto modified railroad flatcars and transported over existing railroad tracks with locomotive power.

- New grade-separated maglev guideways would be constructed on existing railroad rights-of-way, either in an exclusive or shared right-of-way configuration.

3.1 Required Clearance Envelope

If existing railroad corridors are used for future maglev operations, certain mandated horizontal and vertical clearance requirements must be met. The American Railway Engineering Association (AREA) Manual was consulted about possible clearance envelopes that would apply to the project, and that search yielded the following equipment diagrams:

- Plate B - Equipment Diagram for Unrestricted Interchange Service

  This diagram specifies a maximum horizontal dimension of 3.25 meters (10'-8") and maximum vertical dimension of 4.60 meters (15'-1") and is shown on Figure 3-1.

- Plate C - Equipment Diagram for Limited Interchange Service

  This diagram maintains a maximum horizontal dimension of 3.25 meters (10'-8") and increases the maximum vertical dimension to 4.72 meters (15'-6"), and is shown on Figure 3-2.

Numerous contacts were also made to Amtrak's Senior Engineer for Clearances and Tests. Amtrak was extremely helpful and provided clearance information that was more restrictive than that given by AREA. (The two most important telephone conversations with Amtrak are documented in Appendix F.) This information takes into account all physical clearance restrictions wherever Amtrak operates, and was adopted for use on this study.

3.2 Eastern U.S. Summary Clearance Diagram

The Eastern U.S. Summary Clearance Diagram provides the maximum allowable equipment dimensions for unrestricted operation throughout the Amtrak system, and is shown on Figure 3-3. This diagram allows a maximum car height of 4.47 meters (14'-8"), based upon the overhead catenary wire heights located both east and west of New York City's Penn Station. It also allows a maximum horizontal dimension of 3.20 meters (10'-6"), which is based upon the width of the 2-track tunnel under the Hudson River west of Penn Station.

This diagram is applicable to all stations on the Northeast Corridor, where overhead catenary systems are either in place or planned, and include:

- Washington D.C. Union Station;
- Philadelphia 30th Street Station;

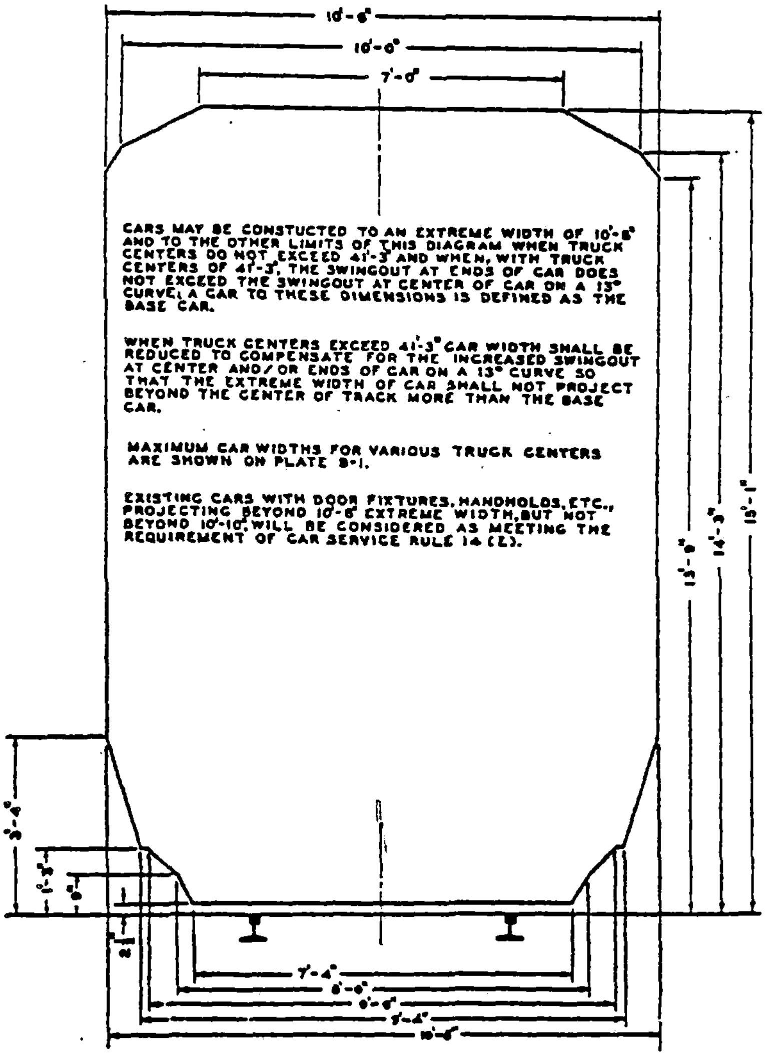
AMERICAN RAILWAY ENGINEERING ASSOCIATION

Part 2
[1]Equipment Diagrams

1975

(Reapproved with revisions 1975)

2.1 EQUIPMENT DIAGRAM UNRESTRICTED FOR INTERCHANGE SERVICE—PLATE B*



THE 2-1/2" ABOVE TOP OF RAIL IS ABSOLUTE MINIMUM UNDER ANY AND ALL CONDITIONS OF LADING, OPERATION, AND MAINTENANCE.

ALL NEW OR REBUILT CARS SHOULD BE SO DESIGNED THAT NO PART OF CAR SHALL BE LESS THAN 2-3/4" ABOVE THE TOP OF THE RUNNING RAIL UNDER ALL ALLOWABLE WEAR AND SPRING DEFLECTION CONDITIONS. THOSE ROADS USING MULTIPLE WEAR WHEELS MAY FIND IT NECESSARY IN MAINTAINING THE 2-3/4" MINIMUM CLEARANCE, TO COMPENSATE FOR WHEELS WORN CLOSE TO THE CONDEMNING LIMIT BY REPLACING WHEEL AND AXLE SETS, BEARINGS OR WEDGES.

*THIS DIAGRAM IS THE SAME AS PLATE B OF THE MECHANICAL DIVISION, A A R, AND IS INCLUDED IN THE A R E A MANUAL FOR CONVENIENT REFERENCE.

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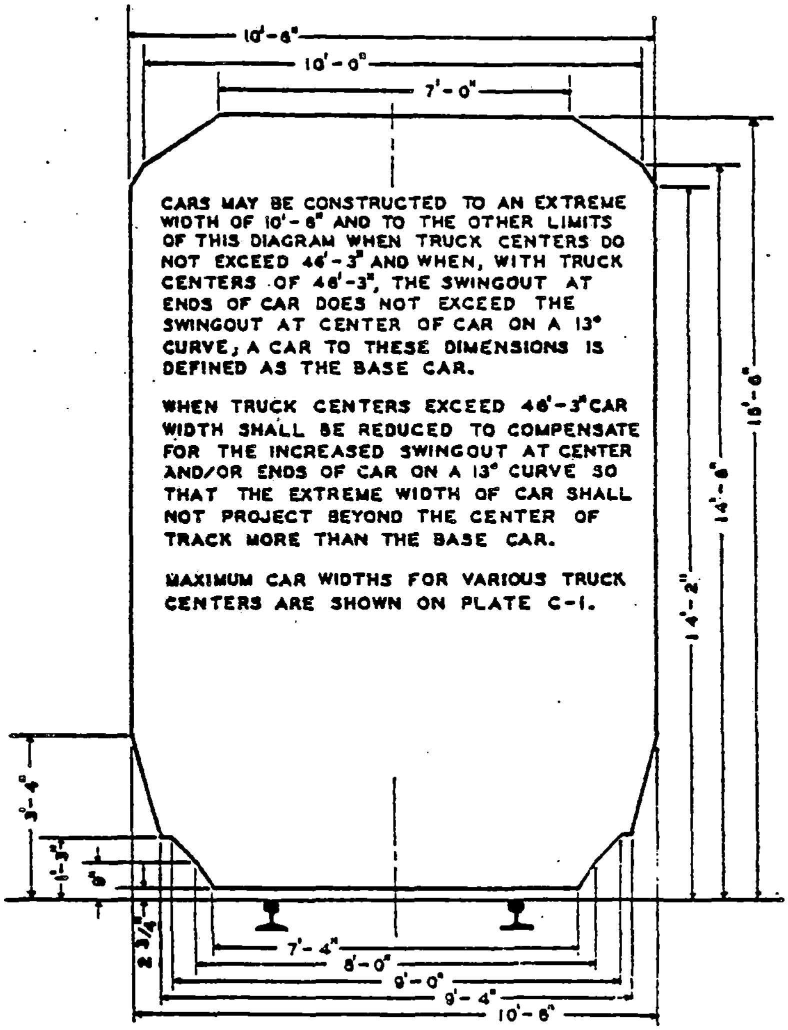
[1] References, Vol. 39, 1938, pp. 427, 877; Vol. 54, 1953, pp. 834, 1332; Vol. 58, 1957, pp. 654, 1207; Vol. 61, 1960, pp. 542, 1024; Vol. 66, 1965, pp. 246, 611; Vol. 76, 1975, p. 233.

[1] *Latest page consist: 1 to 8, incl., (1975).*

FIGURE 3-1

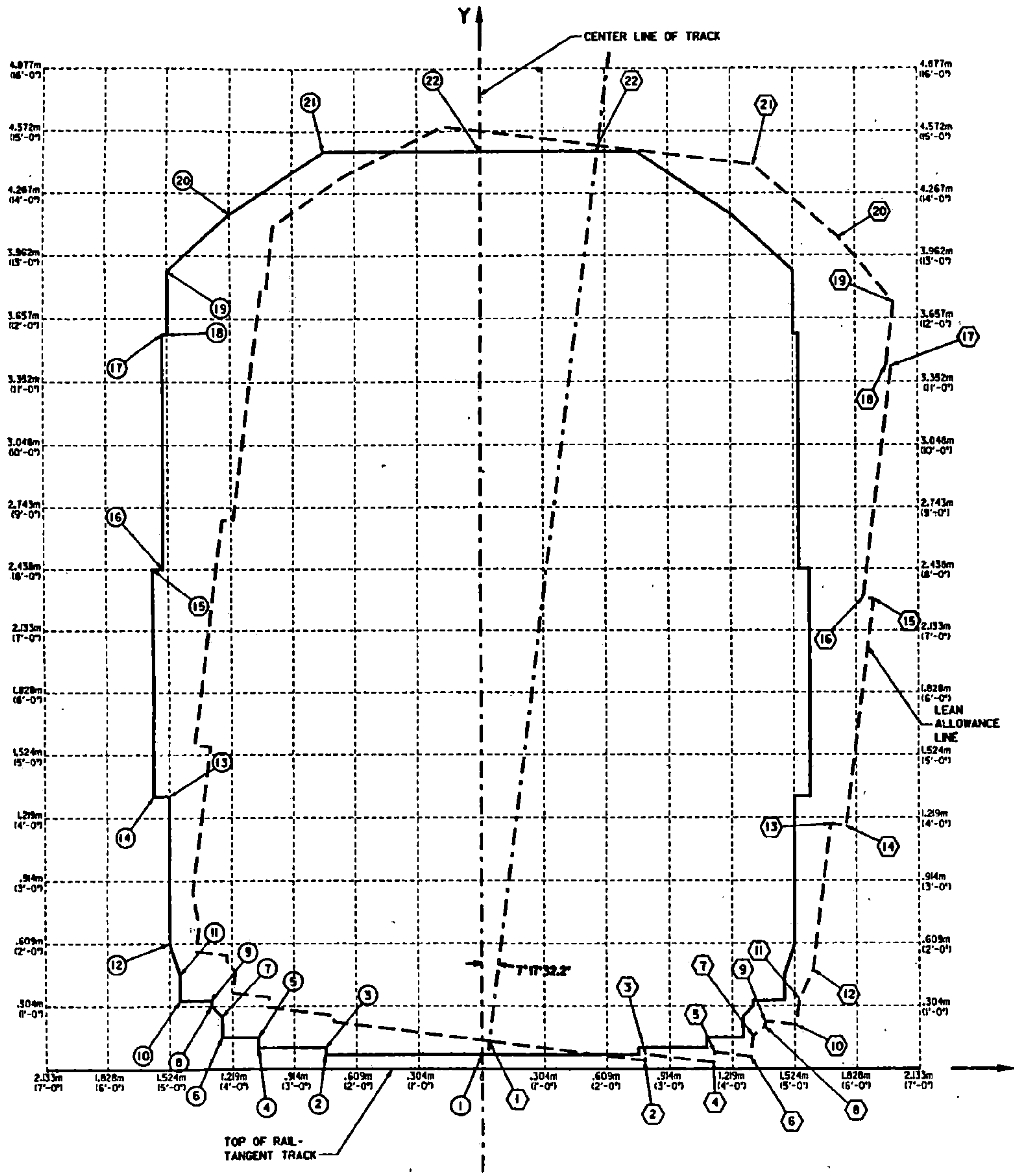
2.3 EQUIPMENT DIAGRAM FOR LIMITED INTERCHANGE SERVICE—PLATE C*



THE 2 3/4" ABOVE TOP OF RAIL IS ABSOLUTE MINIMUM UNDER ANY AND ALL CONDITIONS OF LADING, OPERATION, AND MAINTENANCE.

*THIS DIAGRAM IS THE SAME AS PLATE C OF THE MECHANICAL DIVISION, A.A.R, AND IS INCLUDED IN A.R.E.A MANUAL FOR CONVENIENT REFERENCE. FOR RESTRICTIONS APPLICABLE TO THIS DIAGRAM SEE "RAILWAY LINE CLEARANCES".

FIGURE 3-2



EASTERN TANGENT CLEARANCE DIAGRAM (○) COORDINATES

	METERS		FEET	
POINT	X	Y	X	Y
1	0.000	0.070	0'-0"	0'-2.75"
2	-0.762	0.070	2'-6"	0'-2.75"
3	-0.762	0.102	2'-6"	0'-4"
4	-1.092	0.102	3'-7"	0'-4"
5	-1.092	0.152	3'-7"	0'-6"
6	-1.270	0.152	4'-2"	0'-6"
7	-1.270	0.254	4'-2"	0'-10"
8	-1.321	0.305	4'-4"	1'-0"
9	-1.321	0.330	4'-4"	1'-1"
10	-1.473	0.330	4'-10"	1'-1"
11	-1.473	0.457	4'-10"	1'- 6"
12	-1.524	0.610	5'-0"	2'-0"
13	-1.524	1.321	5'-0"	4'-4"
14	-1.600	1.321	5'-3"	4'-4"
15	-1.600	2.438	5'-3"	8'-0"
16	-1.549	2.438	5'-1"	8'-0"
17	-1.549	3.581	5'-1"	11'-9"
18	-1.524	3.581	5'-0"	11'-9"
19	-1.524	3.886	5'-0"	12'-9"
20	-1.219	4.166	4'-0"	13'-8"
21	-0.762	4.470	2'-6"	14'-8"
22	0.000	4.470	0'-0"	14'-8"

EASTERN ROTATED CLEARANCE DIAGRAM (⬡) COORDINATES

	METERS		FEET	
POINT	X	Y	X	Y
1	0.036	0.133	0'-1.42"	0'-5.24"
2	0.792	0.040	2'-7.18"	0'-1.57"
3	0.796	0.070	2'-7.34"	0'-2.76"
4	1.125	0.037	3'-8.29"	0'-1.46"
5	1.131	0.212	3'-8.53"	0'-8.35"
6	1.308	0.067	4'-3.50"	0'-2.64"
7	1.329	0.168	4'-4.32"	0'-6.61"
8	1.378	0.213	4'-6.25"	0'-8.39"
9	1.381	0.238	4'-6.37"	0'-9.37"
10	1.533	0.223	5'-0.35"	0'-8.78"
11	1.548	0.351	5'-0.94"	1'-1.82"
12	1.618	0.494	5'-3.70"	1'-7.45"
13	1.704	1.201	5'-7.09"	3'-11.28"
14	1.777	1.195	5'-9.96"	3'-11.05"
15	1.917	2.307	6'-3.47"	7'-6.83"
16	1.868	2.310	6'-1.54"	7'-6.94"
17	2.006	3.447	6'-6.98"	11'-3.71"
18	1.981	3.450	6'-5.99"	11'-3.83"
19	2.021	3.752	6'-7.57"	12'-3.71"
20	1.612	4.179	5'-3.46"	13'-8.53"
21	1.329	4.417	4'-4.32"	14'-5.90"
22	0.575	4.496	1'-10.64"	14'-9.01"

NOTES:

1. This drawing is a reproduction of Amtrak Clearance Diagram A-05-1355 (2 sheets) and provides the maximum allowable dimensions for unrestricted operation throughout the Amtrak system.

2. All vertical dimensions represent the maximum dynamic clearance envelope, and must be reduced accordingly to allow for worn wheels, full vertical travel of the suspension system and full passenger loading.

3. The horizontal dimensions represent the maximum static equipment envelope, when measured on level tangent track, subject to the following conditions:

   a. Overall car length of 86'-0" measured over the buffers, with a truck center distance of 60'-0". Any equipment exceeding these dimensions must have the horizontal dimension reduced accordingly.

   b. Maximum degree of curvature is 23°00'. Any equipment negotiating a sharper curve must have horizontal dimensions reduced accordingly.

   c. The horizontal dimensions between the heights of 0'-2.75" and 1'-00" above top of rail represent the maximum static condition of truck parts or carbody parts located directly over the trucks. All other equipment projections between these heights must be constructed so that they do not swing beyond the statically prescribed limits while negotiating 12°30' curve.

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ATLANTA GEORGIA

FIGURE 3-3
Eastern U.S. Summary Clearance Diagram

DESIGN M. GILLAM	SCALE 1" = 1'-0"	DATE MAY 1992
DRAWN J. PARKS	CHECK M. GILLAM	SHEET OF

- New York City Penn Station; and
- Boston South Station Transportation Center.

3.3 Western U.S. Summary Clearance Diagram

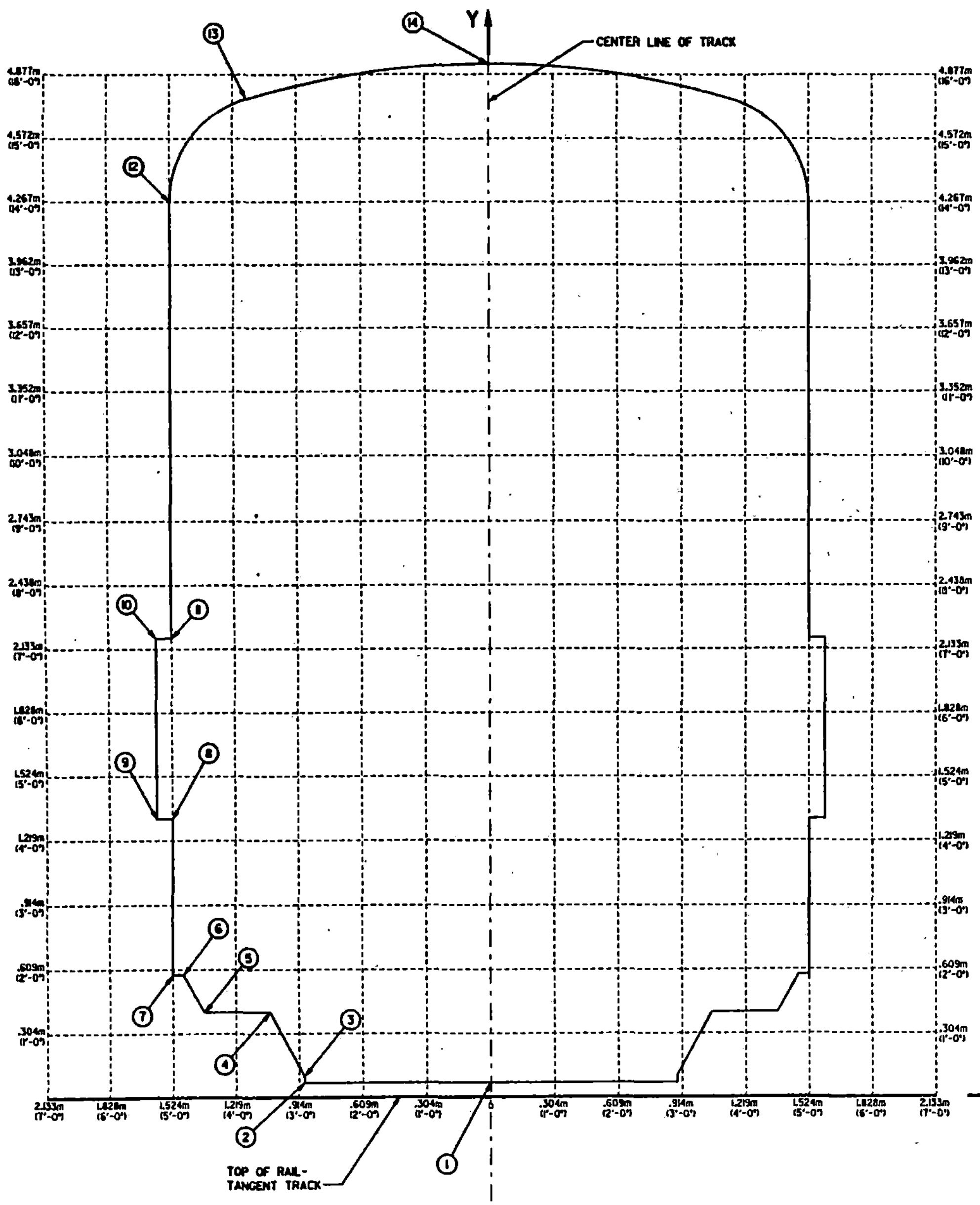
The Western U.S. Summary Clearance Diagram provides the maximum dimensions of bi-level passenger equipment currently operated by Amtrak, and is shown on Figure 3-4. This diagram allows a maximum car height of 4.93 meters (16'-2"), based upon the station roof height at Chicago's Union Station. It also allows a maximum horizontal dimension of 3.20 meters (10'-6"). This diagram is applicable to all stations outside the Northeast Corridor.

3.4 Composite U.S. Summary Clearance Diagram

Both the Eastern and Western U.S. Summary Clearances Diagrams were combined to produce a Composite U.S. Summary Clearance Diagram, shown on Figure 3-5. As can be seen, both clearance diagrams control dimensions in certain areas.

The only area on Figure 3-5 where the Western U.S. Summary Clearance Diagram appears to be the more restrictive condition (outside of the handrail locations on the sides of the clearance envelope) is from 6.99 cm (2.75") above top of rail (TOR) to 0.61 meters (2'-0") above TOR. This situation seems to be illogical since the Eastern U.S. Summary Clearance Diagram takes into account the presence of contact rail traction power systems, as well as train control equipment, and would be expected to control the clearance requirements in that area. However, the Western U.S. Summary Clearance Diagram takes into account the presence of low platforms and any trackside equipment which may be mounted adjacent to those platforms.

It is assumed that low platforms would not be used in conjunction with planned maglev systems because of increased dwell time at stations, consequently, the Eastern U.S. Summary Clearance Diagram was used by



Y
CENTER LINE OF TRACK
TOP OF RAIL-
TANGENT TRACK
4.877m (16'-0")
4.572m (15'-0")
4.267m (14'-0")
3.962m (13'-0")
3.657m (12'-0")
3.352m (11'-0")
3.048m (10'-0")
2.743m (9'-0")
2.438m (8'-0")
2.133m (7'-0")
1.828m (6'-0")
1.524m (5'-0")
1.219m (4'-0")
.914m (3'-0")
.609m (2'-0")
.304m (1'-0")
0

WESTERN TANGENT CLEARANCE DIAGRAM (◯) COORDINATES

	METERS		FEET	
POINT	X	Y	X	Y
1	0.000	0.07	0'-0"	0'-2.75"
2	-0.889	0.070	2'-11"	0'-2.75"
3	-0.889	0.102	2'-11"	0'-4"
4	-1.054	0.406	3'-5.5"	1'-4"
5	-1.372	0.406	4'-6"	1'-4"
6	-1.473	0.584	4'-10"	1'-11"
7	-1.524	0.584	5'-0"	1'-11"
8	-1.524	1.321	5'-0"	4'-4"
9	-1.600	1.321	5'-3"	4'-4"
10	-1.600	2.184	5'-3"	7'-2"
11	-1.524	2.184	5'-0"	7'-2"
12	-1.524	4.267	5'-0"	14'-0"
13	-1.009	4.761	3'-3.72"	15'-7.45"
14	0.000	4.929	0'-0"	16'-2"

1. This is a reproduction of Amtrak's Superliner Construction Outline, and provides the maximum allowabl dimensions of the bi-level passenger equipment currently operated by Amtrak.

2. All vertical dimensions represent the maximum dynamic clearance envelope, and must be reduced accordingly to allow for worn wheels, full vertical travel of the suspension system and full passenger loading.

3. The horizontal dimensions represent the maximum static equipment envelope, when measured on level tangent track, subject to the following conditions:

   a. Overall car length of 86'-0" measured over the buffers, with a truck center distance of 60'-0". Any equipment exceeding these dimensions must have the horizontal dimension reduced accordingly.

   b. Maximum degree of curvature is 23°00'. Any equipment negotiating a sharper curve must have horizontal dimensions reduced accordingly.

   c. The horizontal dimensions between the heights of 0'-2.75" and 1'-00" above top of rail represent the maximum static condition of truck parts or carbody parts located directly over the trucks. All other equipment projections between these heights must be constructed so that they do not swing beyond the statically prescribed limits while negotiating 12°30' curve.

—X

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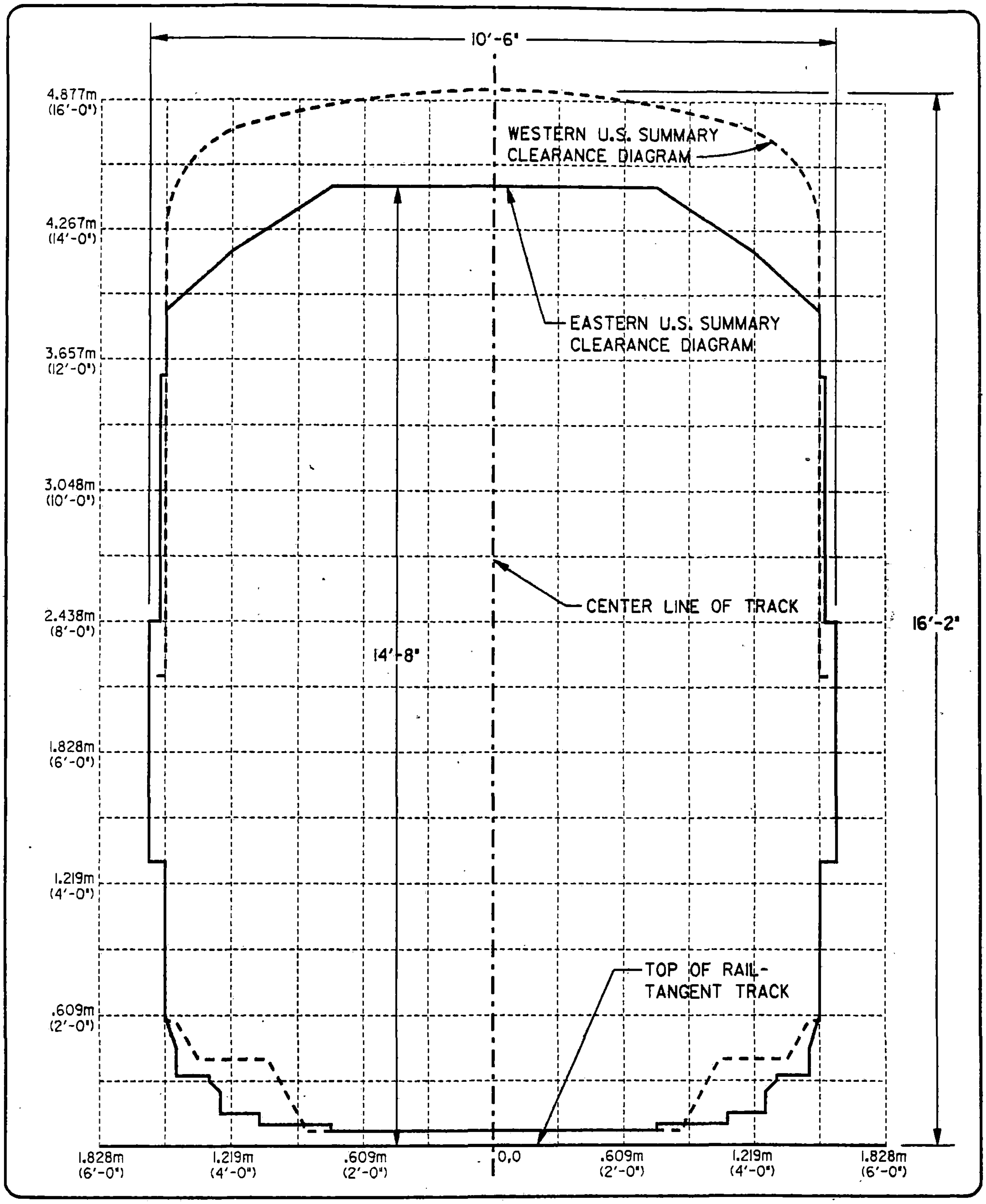
FIGURE 3-4
Western U.S. Summary Clearance Diagram

DESIGN	M. GILLAM	SCALE	1" = 1'-0"	DATE	MAY 1992
DRAWN	J. PARKS	CHECK	M. GILLAM	SHEET	OF



Parsons Brinckerhoff® 100 YEARS

COMPOSITE U. S. SUMMARY CLEARANCE DIAGRAM

FIGURE 3-5

Parsons Brinckerhoff to assess the compatibility of present and planned maglev technologies with existing fixed facilities around the nation. This assessment is discussed in Chapter 4 of this report.

4.0 TESTING OF MAGLEV CONFIGURATIONS

Each of the four selected maglev technologies were evaluated with respect to each of two access methods, henceforth referred to as the "piggyback" mode and the "at-grade" mode. Following are the results of that exercise - superimposing four individual maglev vehicle cross-sections upon two different methods of transportation, while analyzing their impact on the clearance diagram and assessing the advantages and disadvantages of each.

4.1. Grumman "New York State" (Configuration 002) Maglev

Figure 4-1 depicts the Grumman Configuration 002 maglev in both the "piggyback" and "at-grade" modes. As can be seen, the Grumman technology is much too wide to fit within the clearance diagram and would interfere with both high-level and low-level platforms. In the at-grade mode, the magnet undercarriage would require trench construction and would prevent the use of railroad turnouts from the dual-mode guideway. This maglev system also would have a significant impact upon existing structures - requiring major reconstruction at the very least.

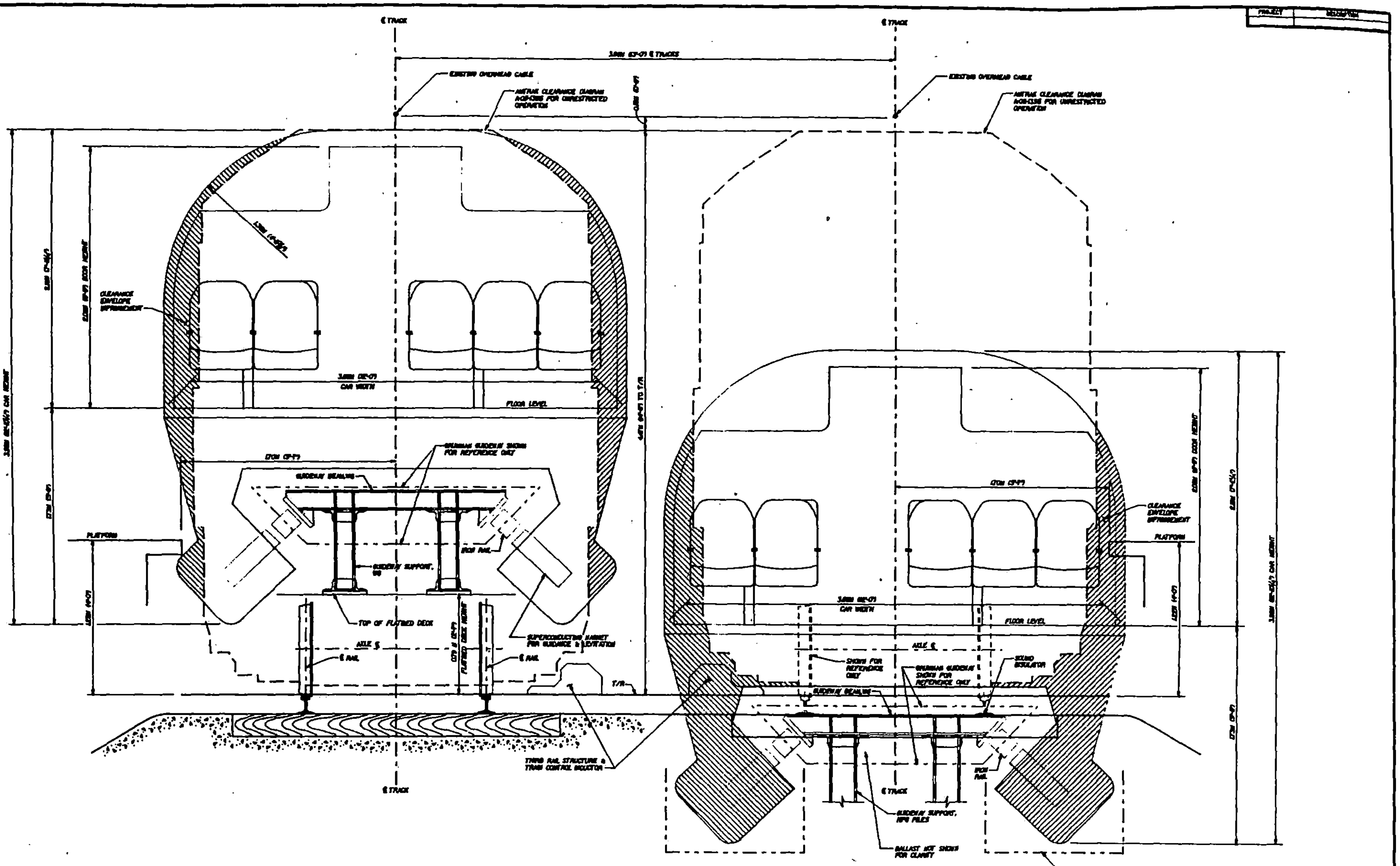
Advantages and disadvantages of the Grumman maglev technology in both the piggyback and at-grade modes are displayed on Tables 4-1 and 4-2, respectively.

TABLE 4-1

MAGLEV SYSTEM
GRUMMAN CONFIGURATION 002 LATEST DEVELOPMENT
ELECTROMAGNETIC SUSPENSION (EMS)

PIGGYBACK

Advantages	Disadvantages
• Levitation independent of speed	• Vehicle does not fit clearance envelope
• Relatively simple guideway structure on railcar carrier	• Could interfere with platform
• Short car - end car 18m (59.04 ft); mid car 12m (39.36 ft)	• Requires two lengths of carrier - 18.3m and 12.2m (60 and 40 ft)
• Good opportunity for resolving major concerns in conceptual design stage	• Tight guideway tolerances
	• In conceptual design stage-No test car built



NOTES:

1. CONTROLLING POINTS:
   - MATCH CAR VERTICAL ℄ WITH CLEARANCE ENVELOPE ℄
   - MATCH CAR TOP WITH CLEARANCE ENVELOPE TOP
2. CONCEPT:
   - INSTALL VERTICAL SUPPORTS AND GUIDEWAY BEAM ON TOP OF THE DECK
   - INSTALL IRON RAIL ON THE GUIDEWAY BEAM
   - SPACING AND ADEQUACY OF THIS STRUCTURE SUBJECT TO DESIGN
3. OBSERVATIONS:
   - CAR TOO WIDE AS SHOWN BY SHADED AREA
   - MAY INTERFERE WITH PLATFORM

Grumman on Flatbed Car

(CONFIGURATION 002 LATEST DEVELOPMENT)

NOTES:

1. CONTROLLING POINTS:
   - MATCH CAR VERTICAL ℄ WITH CLEARANCE ENVELOPE ℄
   - MATCH CAR BOTTOM WITH CLEARANCE ENVELOPE BOTTOM
2. CONCEPT:
   - PUSH OUT EXISTING WOOD CROSSTIES
   - DRIVE HP PILES
   - CONNECT GUIDEWAY BEAM TO PILES
   - INSTALL IRON RAILS
   - SPACING AND ADEQUACY OF THIS STRUCTURE SUBJECT TO DESIGN
3. OBSERVATIONS:
   - CAR TOO WIDE AS SHOWN BY SHADED AREA
   - REQUIRES UNDERGROUND CAR CLEARANCE
   - PLATFORM INTERFERENCE

Grumman at Grade

(CONFIGURATION 002 LATEST DEVELOPMENT)

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FIGURE 4-1

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Grumman Maglev

Configuration 002 - Latest Development

DESIGN V. PATEL	SCALE 1" = 1'-0"	DATE MARCH 1992
DRAWN J. PARKS	CHECK	SHEET OF

4.2 Transrapid Intercity (Transrapid 07) Maglev

Figure 4-2 depicts the Transrapid 07 maglev in both the piggyback and at-grade modes. Again, the Transrapid maglev technology is too wide for the clearance envelope, and would interfere with both high-level and low-level platforms. The magnet undercarriage for the Transrapid maglev would require trench construction in the at-grade configuration, and would prevent the use of railroad turnouts from the dual-mode guideway. This system also would have a major impact on existing structures, with an associated requirement for major reconstruction at the very least.

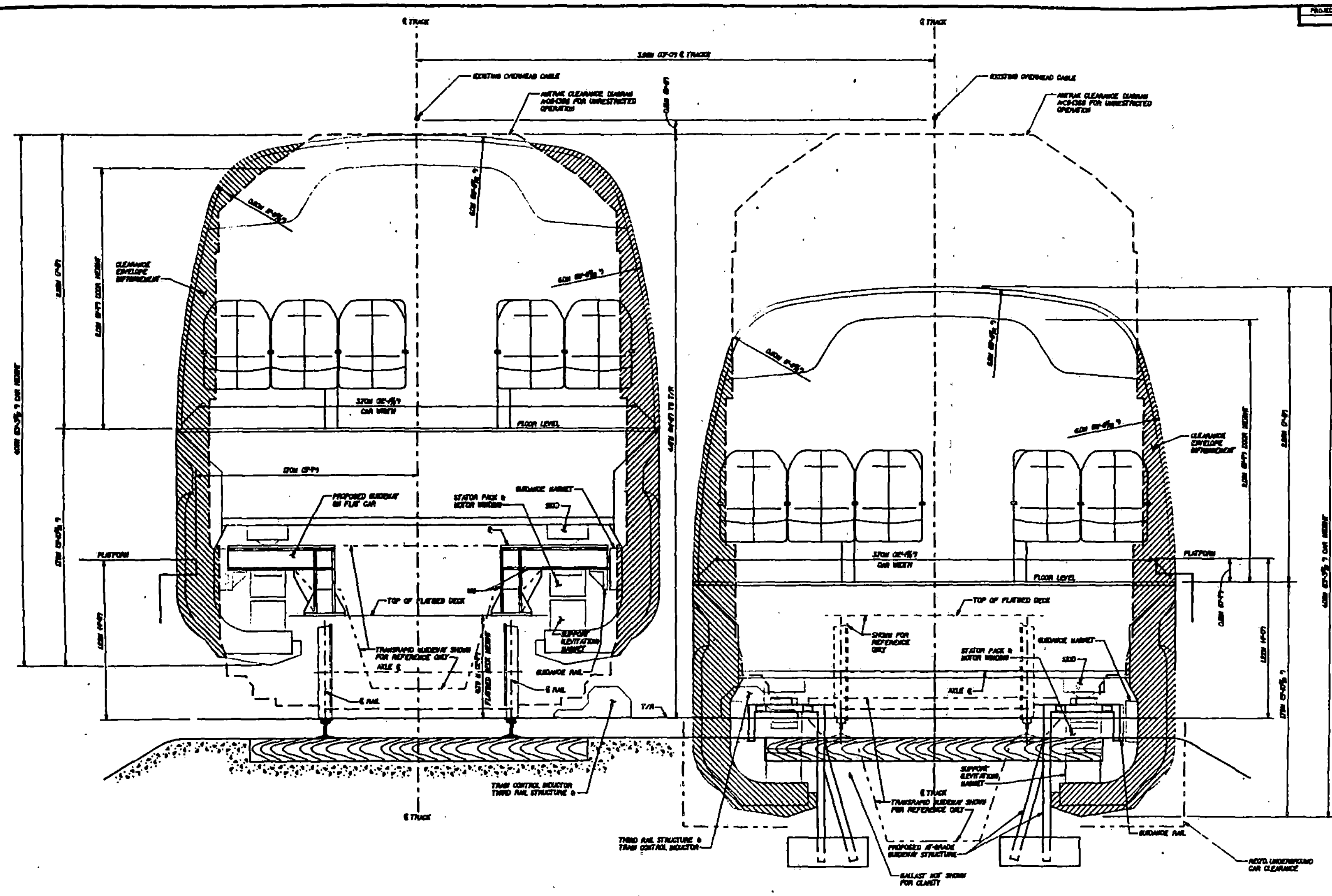
Advantages and disadvantages of the Transrapid maglev technology in both the piggyback and at-grade modes are displayed on Tables 4-3 and 4-4, respectively.

TABLE 4-2

MAGLEV SYSTEM
GRUMMAN CONFIGURATION 002 LATEST DEVELOPMENT
ELECTROMAGNETIC SUSPENSION (EMS)

AT-GRADE

Advantages	Disadvantages
• Levitation independent of speed	• Vehicle does not fit clearance envelope
• Relatively simple modification to existing track structures for conversion to at-grade guideway	• Requires trench construction - cannot tolerate turnouts or structures
• Short car - end car 18m (59.04 ft.) - mid car 12m (39.36 ft.)	• Tight guideway tolerances
• Good opportunity for resolving major concerns in conceptual design stage	• In conceptual design stage. No test car built
	• AT-GRADE APPLICATION IS NOT FEASIBLE BECAUSE OF TURNOUT AND STRUCTURE IMPACTS* *In the context of this study where maglev would use existing railroad infrastructure.



NOTES:

1. CONTROLLING POINTS:
   - MATCH CAR VERTICAL ℄ WITH CLEARANCE ENVELOPE ℄
   - MATCH CAR TOP WITH CLEARANCE ENVELOPE TOP
2. CONCEPT:
   - INSTALL GUIDEWAY STRUCTURE WITHIN AVAILABLE SPACE
   - SPACING AND ADEQUACY OF THIS STRUCTURE SUBJECT TO DESIGN
3. OBSERVATIONS:
   - CAR TOO WIDE AS SHOWN BY SHADED AREA (ZZZZZ)
   - PLATFORM INTERFERENCE
   - MAY NEED USE OF INSIDE WHEEL BEARINGS

Transrapid 07 on Flatbed Car

NOTES:

1. CONTROLLING POINTS:
   - MATCH CAR VERTICAL ℄ WITH CLEARANCE ENVELOPE ℄
   - MATCH SKID BOTTOM WITH CLEARANCE ENVELOPE BOTTOM
2. CONCEPT:
   - INSTALL GUIDEWAY STRUCTURE WITHIN AVAILABLE SPACE
   - SPACING AND ADEQUACY OF THIS STRUCTURE SUBJECT TO DESIGN
   - ALTERNATE GUIDEWAY STRUCTURE, SIMILAR TO BRUNNAU AT-GRADE
3. OBSERVATIONS:
   - CAR TOO WIDE AS SHOWN BY SHADED AREA (ZZZZZ)
   - REQUIRES UNDERGROUND CAR CLEARANCE
   - PLATFORM INTERFERENCE

Transrapid 07 at Grade

FIGURE 4-2

PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.
ENGINEERS PLANNERS
ATLANTA GEORGIA

Transrapid Maglev
Configuration 07

DESIGN V. PATIL	SCALE	DATE MARCH
DRAWN J. PARKS	CHECK	SHEET OF

Parsons Brinckerhoff

4.3 HSST Passive Intermediate Speed (HSST-300) Maglev

The HSST-300 configuration is shown on Figure 4-3 in both the piggyback and at-grade modes. The HSST-300 very nearly meets the requirements of the superimposed clearance envelope and also appears to interface with both high-level and low-level platforms. (Our most recent conversation with Amtrak's Senior Engineer of Clearances and Tests suggests that new railroad equipment is being constructed with a constant 3.20 meters (10'-6") width. That being the case, the HSST-300 maglev would meet the "unofficial" clearance envelope.) In the at-grade mode, elements of the required maglev guideway would interfere with standard railroad equipment operating on the dual-mode guideway and would have to be modified before this technology could be used in the "at-grade" mode.

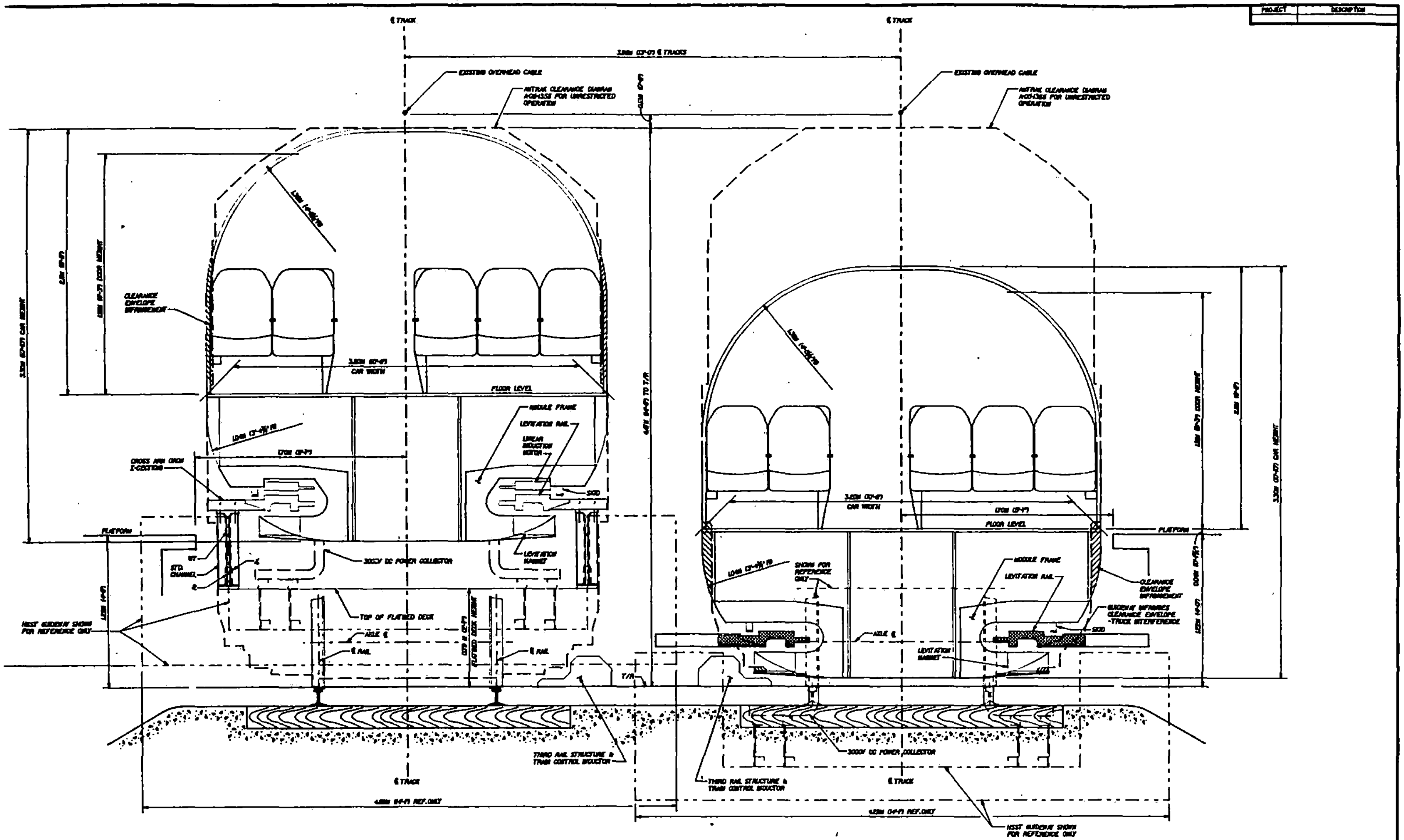
Advantages and disadvantages of the HSST-300 maglev technology in both the piggyback and at-grade modes are shown on Tables 4-5 and 4-6, respectively.

TABLE 4-3

MAGLEV SYSTEM
TRANSRAPID 07
ELECTROMAGNETIC SUSPENSION (EMS)

PIGGYBACK

Advantages	Disadvantages
• Levitation independent of speed	• Vehicle does not fit clearance envelope
• Relatively simple guideway structure on rail car carrier	• Platform interference
• Most advanced MAGLEV technology	• Long vehicle - 27.0m (88'6")
• Ready for commercial application	• Heavy loaded vehicle 58.0mt (127,825 lbs.)
• Can be battery powered for up to 15 minutes	• Tight guideway tolerances
	• Railcar carrier may need inside wheel bearings
	• Restrictive horizontal curve movement



NOTES:

1. CONTROLLING POINTS:
   - MATCH CAR VERTICAL ℄ WITH CLEARANCE ENVELOPE ℄
   - MATCH CAR TOP WITH CLEARANCE ENVELOPE TOP
2. CONCEPT:
   - INSTALL GUIDEWAY STRUCTURE WITHIN AVAILABLE SPACE
   - SPACING AND ADEQUACY OF THIS STRUCTURE SUBJECT TO DESIGN
3. OBSERVATIONS:
   - CAR 4 IN. WIDER AS SHOWN BY SHADED AREA
   - POWER COLLECTOR WOULD REQUIRE MODIFICATION - RETRACTABLE TYPE
   - CROSS ARM WOULD REQUIRE REDESIGN

HSST 300 on Flatbed Car

NOTES:

1. CONTROLLING POINTS:
   - MATCH CAR VERTICAL ℄ WITH CLEARANCE ENVELOPE ℄
   - MATCH CAR BOTTOM WITH CLEARANCE ENVELOPE BOTTOM
2. CONCEPT:
   - INSTALL GUIDEWAY STRUCTURE WITHIN AVAILABLE SPACE
   -
3. OBSERVATIONS:
   - CAR 6 IN. WIDER AS SHOWN BY SHADED AREA
   - GUIDEWAY STRUCTURE PROJECTS WITHIN CLEARANCE ENVELOPE - NO ALTERNATE - WOULD REQUIRE EXTENSIVE REDESIGN
   - GUIDEWAY INTERFERES WITH TRUCK COMPONENTS

HSST 300 at Grade

FIGURE 4-3

Parsons Brinckerhoff 100

PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC. ENGINEERS PLANNERS ATLANTA GEORGIA		
High Speed Surface Transport (HSST) Maglev — Configuration HSST 300		
DESIGN V. PATIL	SCALE 1" = 1'-0"	DATE MARCH 1992
DRAWN J. PARKS	CHECK	SHEET OF

4.4 Japan Railways Vertical Magnet (Configuration MLU 002) Maglev

Figure 4-4 displays the JR configuration MLU 002 maglev in both the piggyback and at-grade modes. As can be seen, the cross-section is within the clearance diagram and appears to interface with both high-level and low-level platforms. In the at-grade mode, it may be possible to utilize the takeoff/landing wheels to support the maglev directly on the standard railroad track structure, with the addition of steel guide wheels to keep the maglev vehicle on the track. This operation would be very similar to that of hi-rail vehicles (i.e. specially equipped automobiles and trucks for use on railroad tracks). The lateral stabilizing wheels would also have to be modified to a retractable type.

Advantages and disadvantages of the JR MLU 002 maglev in both the piggyback and at-grade modes are displayed on Tables 4-7 and 4-8, respectively.

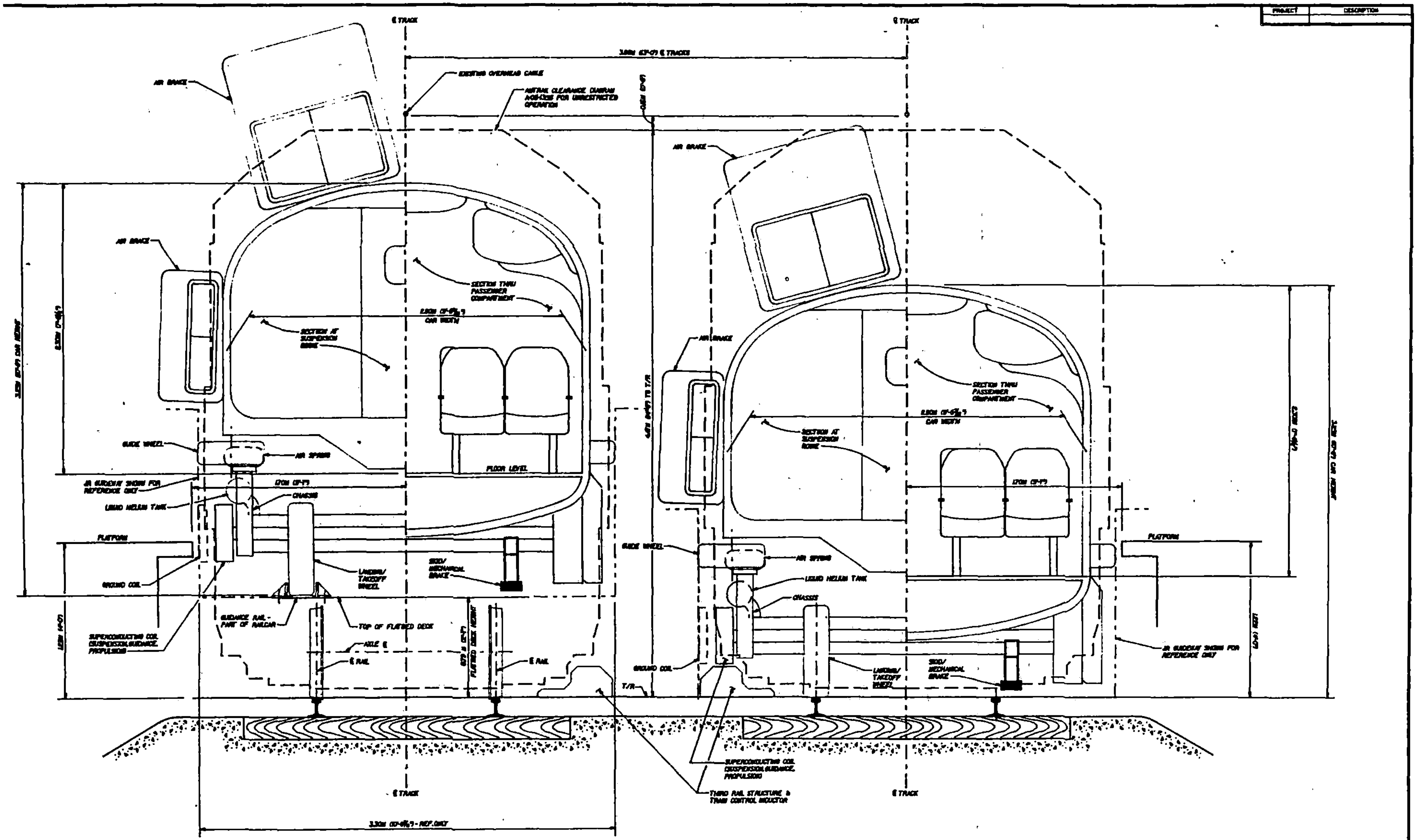
TABLE 4-4

MAGLEV SYSTEM
TRANSRAPID 07
ELECTROMAGNETIC SUSPENSION (EMS)

AT-GRADE

Advantages	Disadvantages
• Levitation independent of speed	• Vehicle does not fit clearance envelope
• Most advanced MAGLEV technology	• Requires trench construction. Cannot tolerate turnouts or structures
• Ready for commercial application	• Platform interference
• Does not need overhead catenary or power pickup. Power is supplied by contactless induction	• Long car 27m (88'6")
• Guideway mountain drive. Can climb steep grades	• Heavy loaded vehicle - 68.0 MT (127,825 lbs.)
	• Tight guideway tolerances
	• AT-GRADE APPLICATION IS NOT FEASIBLE BECAUSE OF TURNOUT AND STRUCTURE IMPACTS*

*In the context of this study where maglev would use existing railroad infrastructure.



NOTES:

1. CONTROLLING POINTS:
   - MATCH CAR VERTICAL ℄ WITH CLEARANCE ENVELOPE ℄
   - SET LANDING/TAKEOFF WHEEL ON TOP OF FLATBED DECK
2. CONCEPT:
   - INSTALL GUIDANCE RAIL ON FLATBED TO MATCH LANDING/TAKEOFF WHEEL GAUGE
3. OBSERVATIONS:
   - PASSENGER COMPARTMENT WITHIN CLEARANCE ENVELOPE
   - MINOR INFRINGEMENT BY LATERAL GUIDEWHEEL
   - MINOR INFRINGEMENT BY BOGIE LOWER PORTION

JR on Flatbed Car

NOTES:

1. CONTROLLING POINTS:
   - MATCH CAR VERTICAL ℄ WITH CLEARANCE ENVELOPE ℄
   - SET LANDING/TAKEOFF WHEEL AT TOP OF RAIL ELEVATION
2. CONCEPT:
   - MODIFY LANDING/TAKE-OFF WHEELS SO THAT THEY CENTER ON TOP OF EXISTING RAIL
   - ADD COMPOSITE LIGHTWEIGHT DESIGN RETRACTABLE GUIDE WHEELS TRAILING LANDING/TAKE-OFF WHEELS
   - USE LOCOMOTIVE FOR TRAIN OPERATION SIMILAR TO CONVENTIONAL TRAINS
3. OBSERVATIONS:
   - SIMILAR TO FLATBED CONCEPT

JR at Grade

Parsons Brinckerhoff

FIGURE 4-4

PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.
ENGINEERS PLANNERS
ATLANTA GEORGIA

Japan Railways Maglev
Configuration MLU 002

DESIGN V. PATIL	SCALE 1" = 1'-0"	DATE MARCH [illegible]
DRAWN J. PARKS	CHECK	SHEET OF

TABLE 4-5

MAGLEV SYSTEM
HSST 300
ELECTROMAGNETIC SUSPENSION (EMS)

PIGGYBACK

Advantages	Disadvantages
• Short car - 22m (72.18ft.)	• DC power collector would need modification to retractable type
• Levitation independent of speed	• Technology still under development - Las Vegas track will be used to test high speeds. (HSST 200 built and tested at low speeds)
• Can negotiate 250 m (820 ft.) horizontal curve	• Minor impact upon clearance envelope
• Simple guideway	
• Loaded vehicle weighs only 30 MT (66,000 lbs.)	
• Well suited for piggyback	
• Good opportunity for resolving major concerns in conceptual design state	

TABLE 4-6

MAGLEV SYSTEM HSST 300
ELECTROMAGNETIC SUSPENSION (EMS)

AT GRADE

Advantages	Disadvantages
• Short car - 22 m (72.18 ft.)	• Minor impact upon clearance envelope
• Levitation independent of speed	• AT-GRADE APPLICATION IS NOT FEASIBLE BECAUSE OF GUIDEWAY INTERFERENCE WITH RAILROAD EQUIPMENT*
• Can negotiate 250 m (820 ft.) horizontal curve	
• Simple guideway	
• Loaded vehicle weighs only 30 MT (66,000 lbs)	
• Good opportunity for resolving major concerns in conceptual design state	*In the context of this study where maglev would use existing railroad infrastructive.

TABLE 4-7

MAGLEV SYSTEM
JR MLU002
LATEST DEVELOPMENT
ELECTRODYNAMIC SUSPENSION (EDS)

PIGGYBACK

Advantages	Disadvantages
• Least infringement of all maglev systems studied	• Longest end car of all systems studied 27.5 m (90.2 ft.)
• Large suspension gap - 100 mm (3.94 in.) Does not need tight guideway tolerances. Provides clearance for obstacles or snow	• Full development 10+ years in future
• Light weight permitting heavier payloads	• Uses aerodynamic braking which infringes on clearance envelope when open
• Designed for underground operation suitable for operation in U.S. tunnels	• Uses suspension bogies between adjoining cars. Compatibility with carrier coupler needs to be established
• Good opportunity for resolving major concerns in conceptual design stage	• Requires two lengths of carrier - 27.4 m and 21.6m (90 and 71 ft.)

TABLE 4-8

MAGLEV SYSTEM
JR MLU002 LATEST DEVELOPMENT
ELECTRODYNAMIC SUSPENSION (EDS)

AT-GRADE

Advantages	Disadvantages
• Least infringement of all systems studied	• Longest end car of all system studied 27.5 m (90.2 ft.)
• Minimal changes to the existing rail structure	• Full development 10+ years away
• Good candidate for push-pull operation by relocating rubber tires to match existing rail gauge and using steel guide wheels	• Lateral stabilizing wheels would have to be modified to retractable type
• Designed for underground operation suitable for operation in U.S. tunnels	• Landing wheels must be relocated to match rail gauge. Steel guide wheels would be required
• Light weight permitting heavier payload	
• Good opportunity for resolving major concerns in conceptual design stage	

4.5 Conclusions

Table 4-9 summarizes the results of this preliminary feasibility analysis for the four maglev designs and the two transportation modes. At this point, only the JR MLU 002 may work in the at-grade mode, however, only if the required modifications to the suspension bogies and takeoff / landing wheels can be made and the guide wheels added. Both the HSST-300 and JR MLU 002 appear feasible in the piggyback mode; however, the HSST-300 configuration may require a minor reduction in width. The JR design has the advantage of being able, with minor modification, to run on existing rails on its own or to be accommodated on board a rail car carrier, but its development is at least ten years away and very little information was available during the course of the study on which to base meaningful conclusions.

At this time, the required clearance envelope for unrestricted operation on existing railroad corridors in the United States precludes use of the Grumman and Transrapid maglev systems in either the at-grade or piggyback modes because of their excessive width and wrap-around body designs. However, further investigation of individual corridors in the United States could identify facility and / or operational modifications that would permit use of these wider technologies to access center city terminals.

The HSST-300 maglev configuration, at this point, appears to be the only technology with a reasonable development timeframe that meets the Eastern United States summary clearance diagram. (This assumes that an overall vehicle width of 3.20m (10'-6") is acceptable at a height greater than 2.18m (7'-2") above the top of rail, an assumption which is presently being acted upon in the construction of new Amfleet III Horizon rail vehicles.) As a result, the HSST-300 maglev technology was carried forward in this study for the investigation of a maglev-rail car carrier intermodal concept.

TABLE 4-9

PROJECT BAA-206
MAGLEV - RAIL INTEMRODAL EQUIPMENT & SUSPENSION
CONCLUSION

ACCOMMODATION WITHIN CLEARANCE ENVELOPE

	HSST	JR	GRUMMAN	TRANSRAPID
AT-GRADE	NO	POSSIBLY	NO	NO
PIGGYBACK	**YES**	POSSIBLY	NO	NO

5.0 MAGLEV - RAIL CAR CARRIER INTERMODAL CONCEPT

To enable the selected maglev vehicle (the HSST-300 maglev) to transition from the high-speed levitated mode to the rail carrier mode (i.e., the "piggyback" mode), certain essential design criteria have to be established. These criteria would include:

- a location with compatible land use characteristics;
- adequate right-of-way to accomplish the intended function (or the possibility of obtaining same in a cost-effective manner);
- a site which minimizes the travel time in the "piggyback" mode;
- a site with adequate infrastructure (i.e., electric power, drainage, transportation access) or the ability to obtain same relatively inexpensively; and
- a site which minimizes the time of the transfer process.

Additionally, coordination between the maglev fixed guideway designers and the existing railroad corridor operators, such as Amtrak, would be required. Obviously, the time element and degree of complexity of the transfer process itself pose unique problems. The whole concept of high-speed intercity travel should not be degraded by a time-consuming modal transfer operation in the middle of a passenger's journey.

5.1 Transfer Scenario

To achieve the most efficient arrangement for the transfer scenario, it was decided to terminate the maglev guideway adjacent to the existing railroad corridor at a location which would accommodate a train of at least ten rail car carriers with additional space for the locomotive. Currently available Amtrak-style motive power equipment would be satisfactory for propulsion. At the same time, the location would be as close as possible to the center city terminal to minimize the travel time in the piggyback mode.

Basically, the maglev train set would arrive at the transfer point sufficiently slowed to about 1.8 meters per second (4 mph) where it would glide onto a parked set of coupled rail carriers. When located properly and locked down to the rail car carrier, the now piggybacked consist would be pulled to the center city terminal station by locomotive.

This process could be refined to provide a transfer time of about three to four minutes, not unreasonable considering the travel time savings accrued at this point by the high-speed technology. During this period, the maglev passengers would remain aboard, being adequately provided with essential car services (i.e., lighting, heating, air conditioning) from the maglev car battery system during the transfer process, and from conventional 480v three-phase AC head end power (HEP) from the pulling locomotive after the maglev train has been locked into position on the rail car carrier. Alternatively, portable power pickups could be attached to the maglev train prior to departure from the maglev guideway. The maglev/rail car carrier "transfer station" should be provided with a few basic features such as:

- a full-length side platform at the appropriate piggy-backed maglev floor height, to allow access/egress to or from the maglev as necessary;
- a full length canopy to shield the equipment from inclement weather; and
- exterior lighting for night operations.

5.2 Rail Car Carrier Minimum Requirements

To transport the selected maglev vehicle, the rail car carrier would need certain basic design and performance features to provide optimal piggy-backing service. For the purpose of this study, we have assumed that the maglev "unit train" is made up of 10 cars; one cab unit at each end with eight intermediate cars. The physical lengths of the rail carrier cars, of course, will be matched to those of the maglev units to position the couplers on the maglev vehicles over the couplers of the rail car carrier. For example, the cab cars are about 1.8 m (6 feet) longer than the intermediate cars in the HSST Model 300. This will facilitate proper curve negotiation when running on conventional trackwork.

During the initial concept study, it was envisioned that the rail carrier could be of the articulated style used with trailer-on-flatcar/container-on-flatcar (TOFC/COFC) services available on freight railroads. However, as the details and physical constraints were further studied, it became apparent that this simpler arrangement could not be used. Axle loadings and larger than normal truck centers placed unacceptable restrictions on the carrier design. (Appendix A displays calculations that show a reduction in the width of the maglev vehicles would be necessary to conform to the Composite U.S. Summary Clearance Diagram if articulated trucks are used.) Having established these parameters, the rail carrier required two different lengths to conform to the HSST-300 cab units which are 22 meters (72.18 feet) long and the intermediate cars which are 20 meters (65.62 feet) long. Each rail carrier would need two identical bogies. Other pertinent design requirements for these carriers have been listed below (not in any particular order).

	End Units		Intermediate Units	
• Length over striker faces	23.22M	(76'-2 3/16")	20M	(65'-7 7/16")
• Truck centers	15.91M	(52'-2 3/16")	13.90M	(45'-7 7/16")
• Maximum external width	3.2M	(10'-6)	3.2M	(10'-6)
• Tare (light) weight	24.9MT	(55,000 lbs)	22.7MT	(50,000 lbs)
• Load capacity	29.9MT	(66,000 lbs)	29.9MT	(66,000 lbs)
• Brake equipment	26C EP		26C EP	
• Couple	AAR TIGHTLOCK		PERMANENT TYPE	
• Truck features	Two-axle, outboard bearing, cast or fabricated frame and bolster with disc brakes and automatic hand brake (spring applied - air release.) Rubber primary suspension, air bag			

secondary with full hydraulic damping in vertical and lateral directions.

- Car construction — All welded fabrication using LAHT steel plates, shapes and sheet. Fully conforming to AAR standards for passenger equipment.

5.3 Survey of Available Rail Car Market

Having selected the HSST-300 maglev system design, and developed the basic criteria requirements for a rail car carrier described in the previous section, a survey of the available rail car market was initiated.

The upsurge of TOFC/COFC freight services in the United States over the last decade has yielded many innovative styles of flat cars from the traditional manufacturers. The trend has been to low mass, high capacity cars - cost-effective designs that are easy to maintain. Current flatcar types and future plans for next-generation carriers were obtained from trade publications, telephone surveys with manufacturers and data from exhibitions. This information is included in Appendix B.

This survey indicated that currently available railroad flatcar equipment could not fully comply with the needed requirements. Containers and road trailers do not exhibit the same physical characteristics that have emerged from the maglev design study. Realizing that "off the shelf" cars would have to be drastically modified to suit the purposes of this project, it was clear that rail car carriers would need to be virtually custom built. (If other maglev system designs are considered, then this position may have to be reevaluated.) However, much useful information has been gathered during the industry review, particularly with regard to lightweight design methods for the body construction, attachment techniques and ancillary equipment.

5.4 Rail Car Carrier Definition

Having established the conceptual rail car carrier requirements and incorporated the most useful construction details from the available rail car market, these elements will be expanded in this section to describe in more detail the features and arrangements of a conceptual rail car carrier for the HSST-300 series maglev.

Our early studies of maglev technology characteristics directed our thoughts toward using the maglev train to propel itself under full levitation onto the rail car carrier train set with no other external assistance. Early investigation also led to the belief that passenger ride comfort and noise isolation could best be achieved by keeping the levitation system in operation during the piggyback journey. However, after much deliberation, the complexities of supplying levitation electric power when in this mode, together with physical operational problems, (e.g., heat generation and dissipation), it was apparent that a simpler method had to be found.

Further investigation into the matter showed that it would be feasible to fit groups of pneumatic "rollers" to the last 214 m (700 feet, the approximate length of a 10-car train), of the maglev guideway and also on the full length of the rail car carrier train set. The thought is that the maglev train could best be handled by rows of these "rollers" (or tires) being alternately powered and unpowered, thus moving the maglev off the last section of its unique guideway and along the deck of the rail car carrier train (see Figure 5-1). This concept is believed to have less power supply problems and would by design provide a degree of maglev/rail carrier "cushioning" and noise and vibration isolation. Small electric motors with reduction gear units would provide roller rotation, with electric power permanently installed in the short section of maglev guideway. Electric power would also be supplied to the carrier train set by an automatic electric coupling located at the head end, adjacent to the locomotive. Of course, no roller power would be required and would be disconnected when the piggybacked train is moving. This design is well within the current state-of-the-art in the railroad industry and would offer, we believe, the most cost-effective solution to this transfer process. If such a project is advanced further, more complete engineering analysis will be necessary, specifically in the areas of:

- safety interlocking for the tie-down devices and parking brakes;

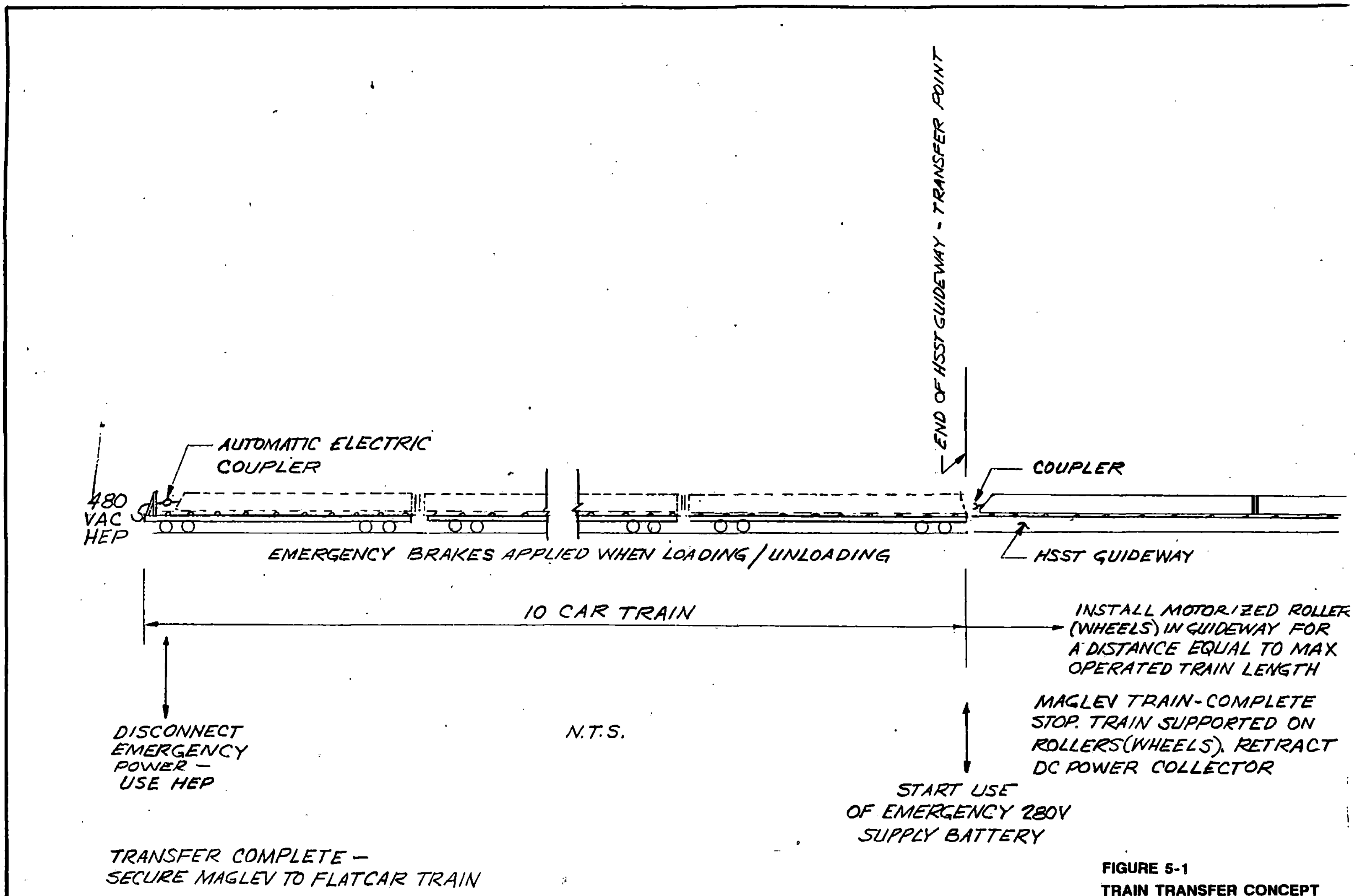


FIGURE 5-1
TRAIN TRANSFER CONCEPT

- some form of communication between the maglev crew and locomotive; and
- methods of ensuring easy operations in inclement weather.

5.5 The Transition Process

Our investigations have led to the opinion that a feasible transition process can be achieved in a reasonable time frame with little or no passenger disruption. Mention has been made earlier about reducing this mode change period so as to enable operators of such intercity maglevs to minimize true city center to city center journey times. We believe that the whole transitioning process should be designed so that this time "delay" is in the region of four to five minutes.

The proposed maglev to rail car carrier transition process, assuming a journey from another city into the center city terminal, is shown on Figure 5-1 and is described below:

1. Inbound maglev trains would decelerate from their maximum cruising speed to about 1.8 meters per second (4 mph) and would stop on the end of the guideway which would be fitted with pneumatic rollers.

2. Levitation would be discontinued, the DC power collectors would be retracted and 280v battery power for on-board auxiliary (i.e. heating, lighting, air conditioning) would commence. At this point, the maglev set would be supported by the pneumatic roller system.

3. The pneumatic roller system would be energized and would move the maglev train onto the rail car carrier train set. At its final location, the maglev train would be locked down, perhaps by pneumatic tie-down latches. Head end power (HEP) and voice communications connections would be established. (All of the above described functions could be automated if desired.)

4. The maglev/rail carrier combination would then be moved under the power of the locomotive unit to the center city terminal station.

5. This system would work in reverse order for the outbound move. To alleviate the need for the locomotive to be on the head end in the outbound movement, it may be possible to install a control panel in the trailing cab unit of the maglev train. In this manner, outbound trains could be "pushed" by the locomotive which would allow a quicker turnback and would simplify terminal operations. However, this would require controls at both ends of the maglev train and could be cost-prohibitive.

Figures 5-2 through 5-7, attached hereto, explain various aspects of the proposed rail car carrier system in more detail.

5.6 Suspension Characteristics and Design

To conduct a ride quality analysis, maglev and intermodal car suspension parameters must first be defined. A preliminary suspension design was therefore generated to provide these parameters, based on established engineering practices in passenger rail vehicle design and assumed alignment and track conditions.

For the maglev vehicle, a secondary suspension was assumed at each of the five magnet support frames (unsprung masses) of the HSST-300 vehicle. Figure 5-8 displays a sketch of the maglev/rail car mode developed for the ride quality analysis. A 1 Hz vertical natural frequency was assumed for the loaded maglev car (23,350 kg sprung car body mass) with 25 percent of critical damping. This combination would provide good ride quality for the maglev vehicle on its normal guideway. Natural frequencies of other rigid-body modes would range from 0.68 Hz (yaw) to 0.88 Hz (pitch). A first vertical body bending mode of 6.5 Hz was chosen as typical of a vehicle this long.

It is assumed that the pneumatic roller system would contact the magnet support frames, rather than the car body, with five roller sets per frame. Stiffness and damping values for the roller tires were chosen to be representative of similar automotive-type tires. A vertical deflection of about 13 mm (0.52 inches) would be typical under the loaded maglev car. The primary suspension of the intermodal car is assumed to be a relatively stiff set of elastomeric bushings. An

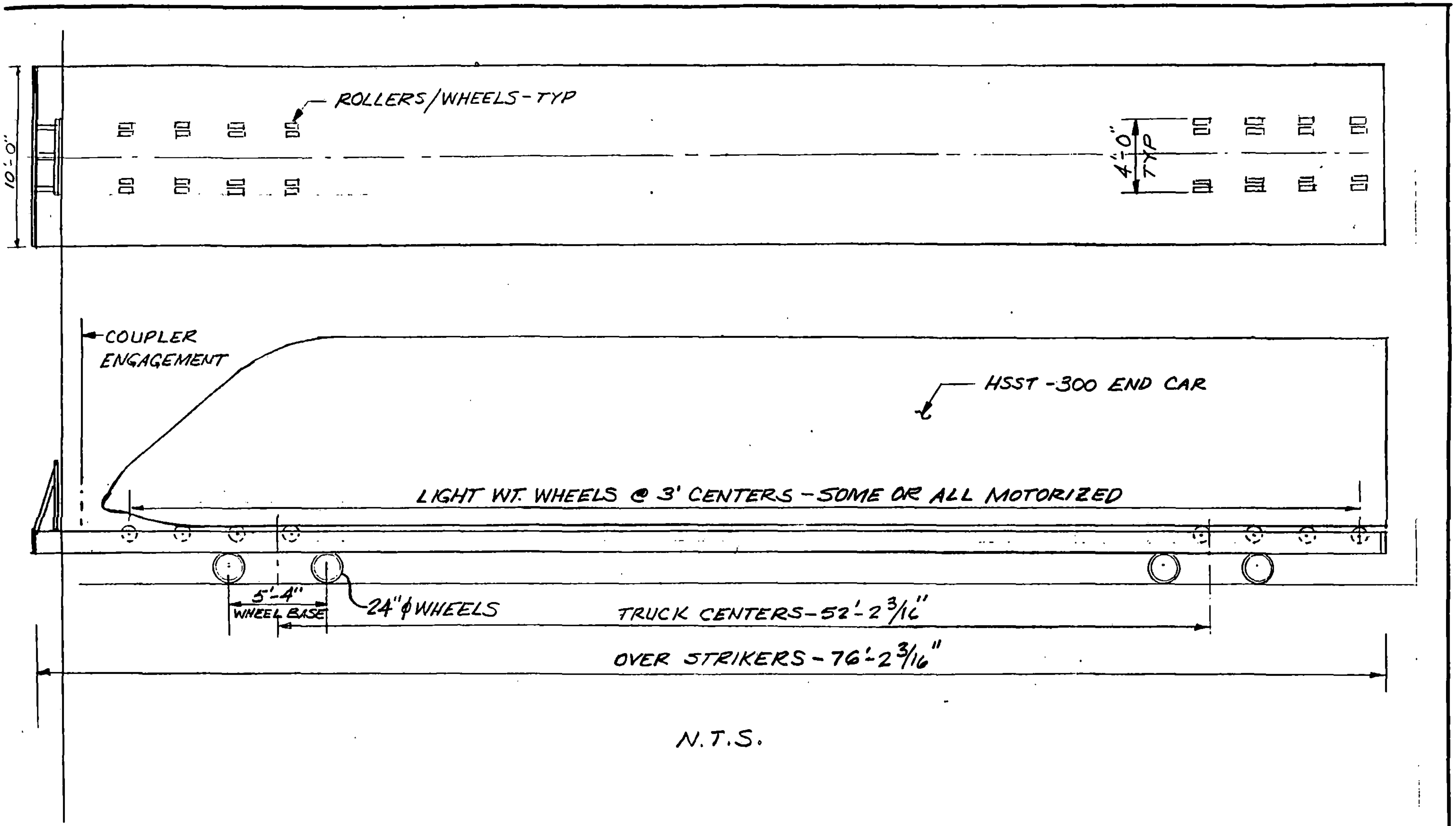


FIGURE 5-2
TRANSFER CONCEPT - ELEVATION

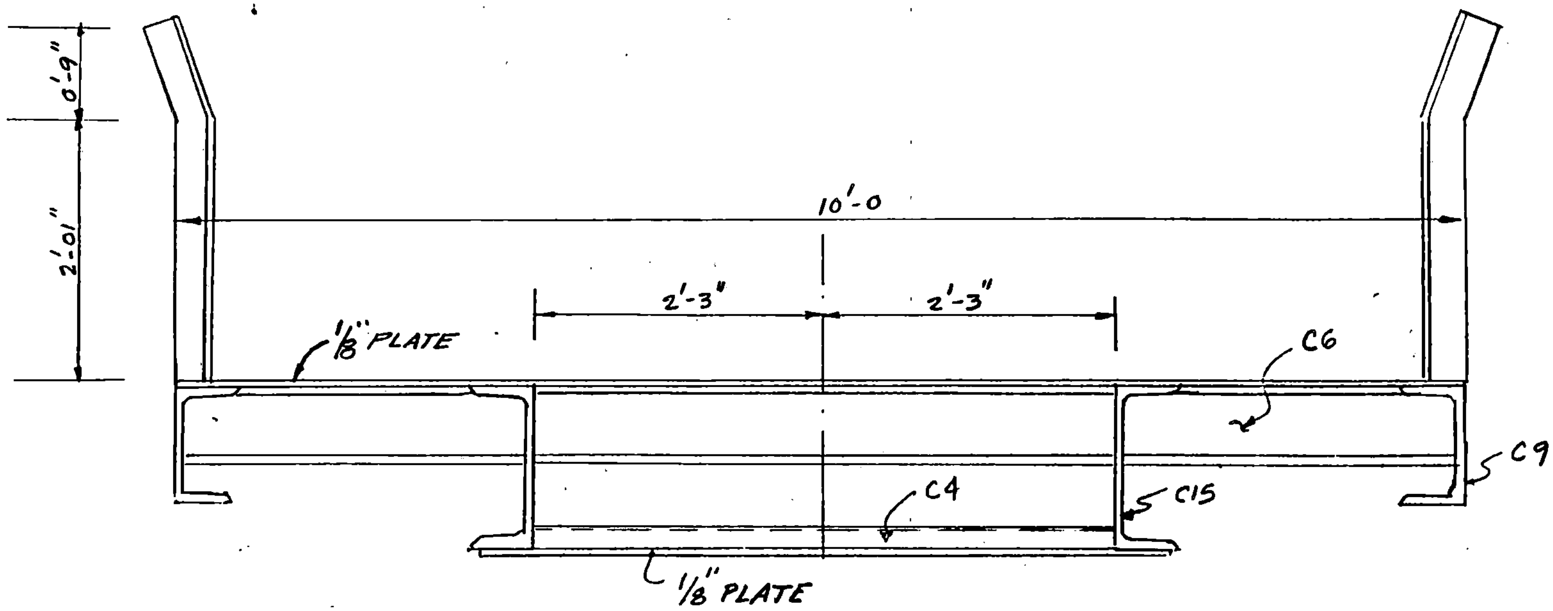


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FIGURE 5-4
TYPICAL SECTION
SECTION A-A

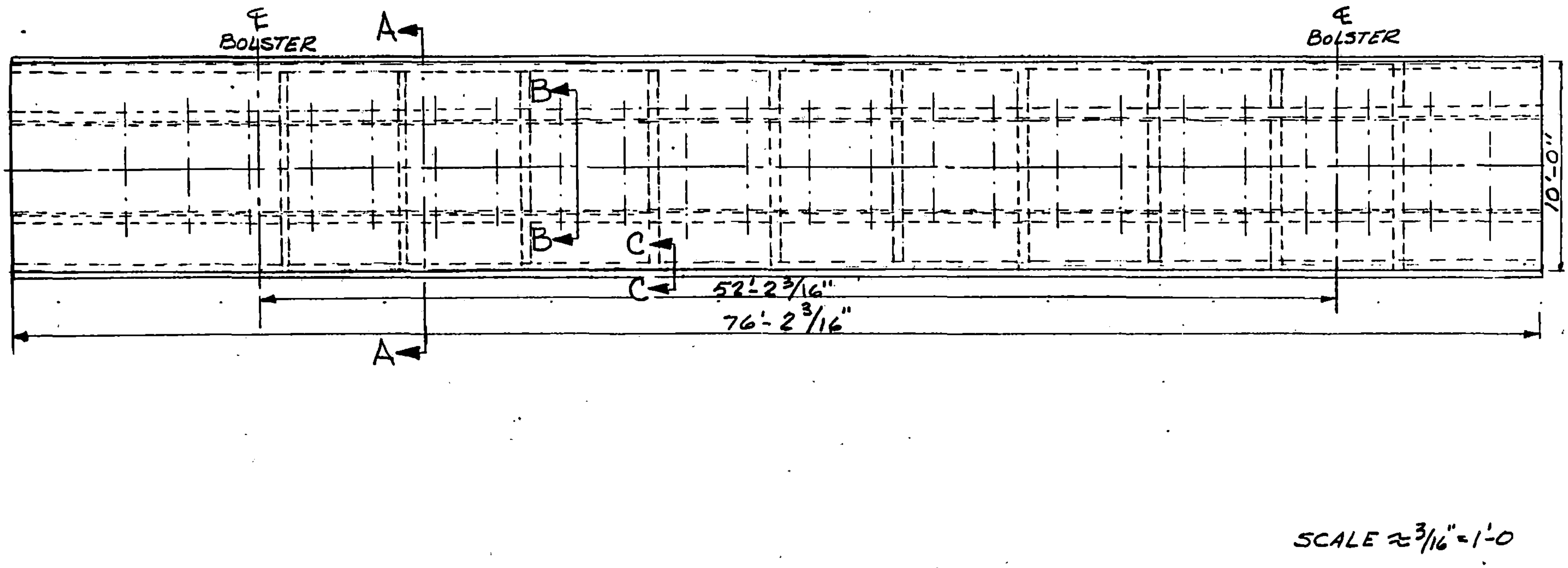


FIGURE 5-3
TRANSFER CONCEPT - UNDERFRAME PLAN

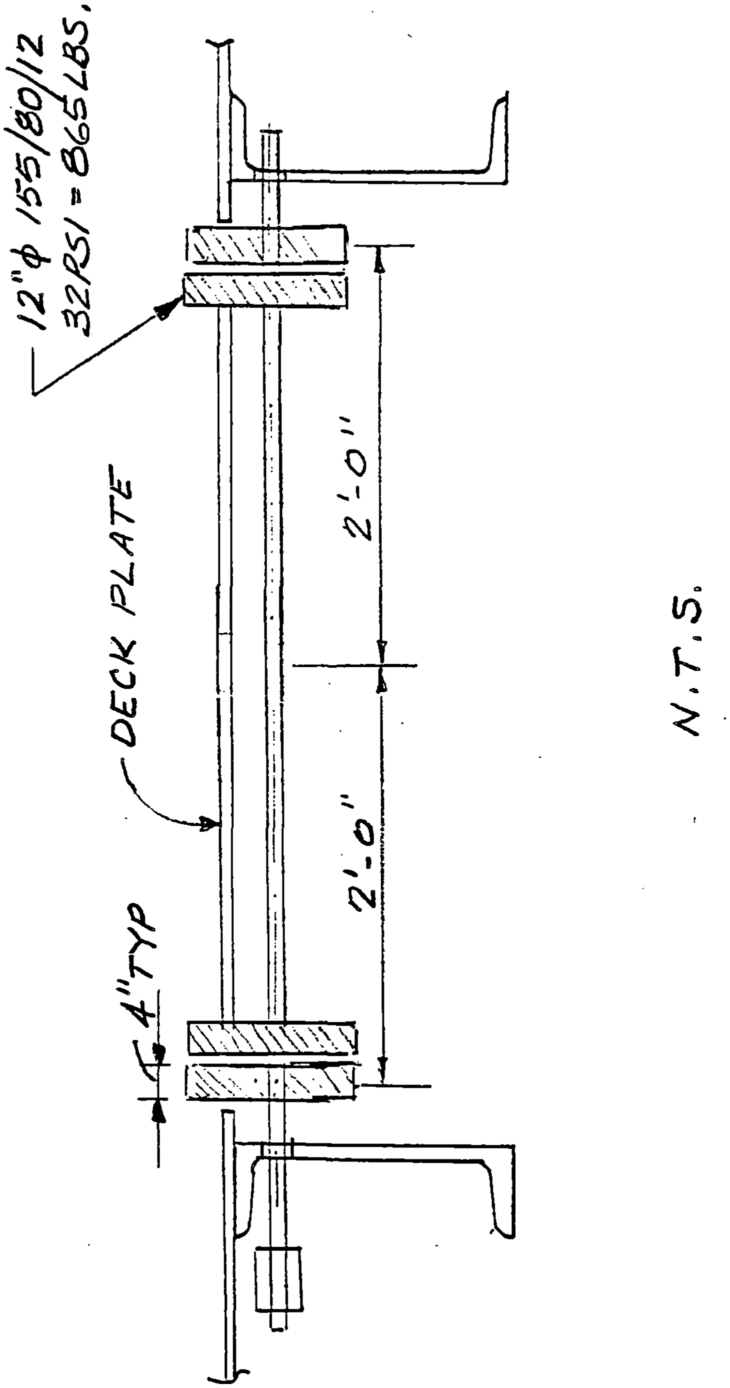


FIGURE 5-5
TYPICAL SECTION
SECTION B-B
MOTORIZED ROLLER WHEELS

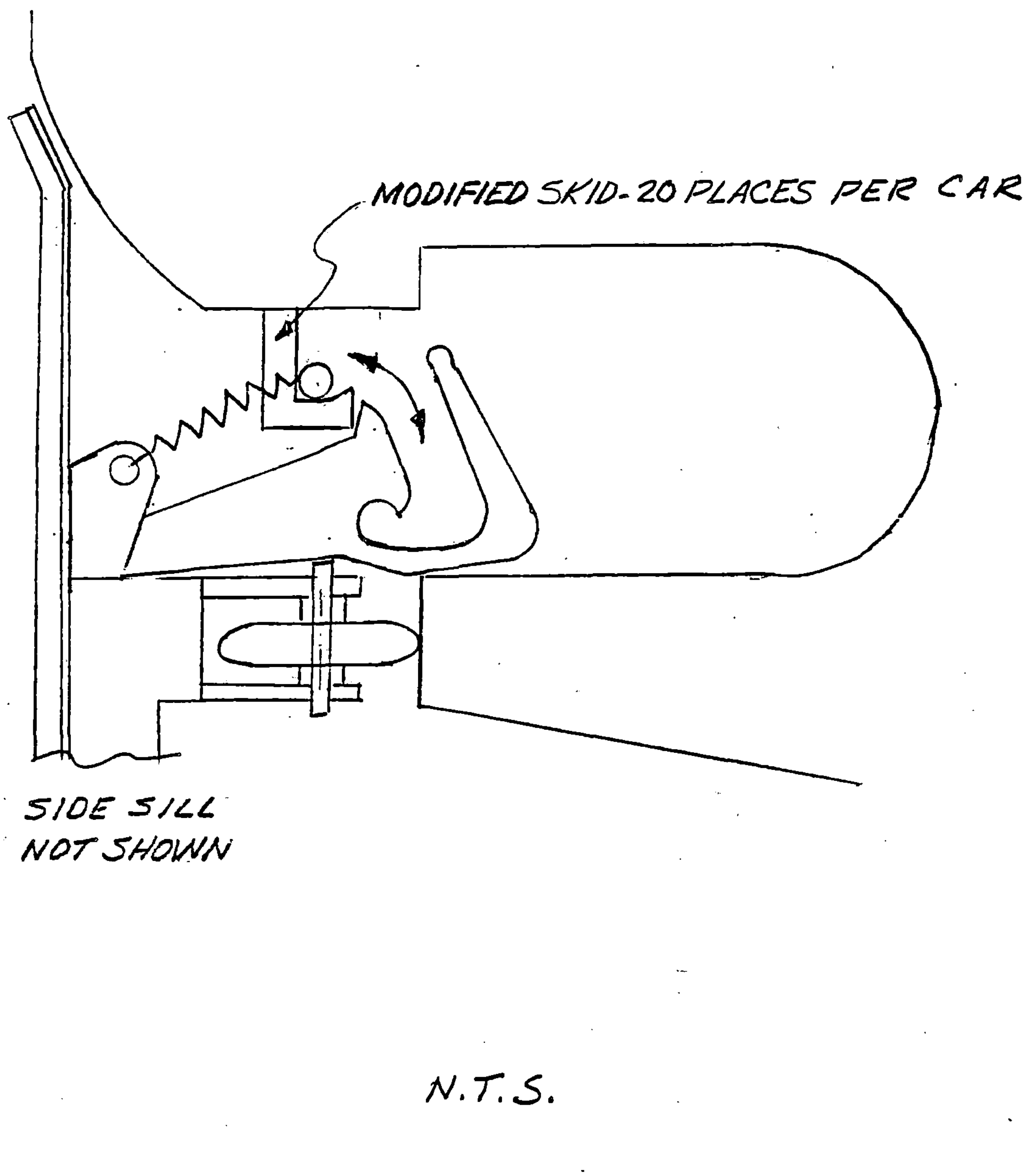


FIGURE 5-6
SECTION C-C
CAR LATERAL GUIDE AND SECUREMEN DEVICE

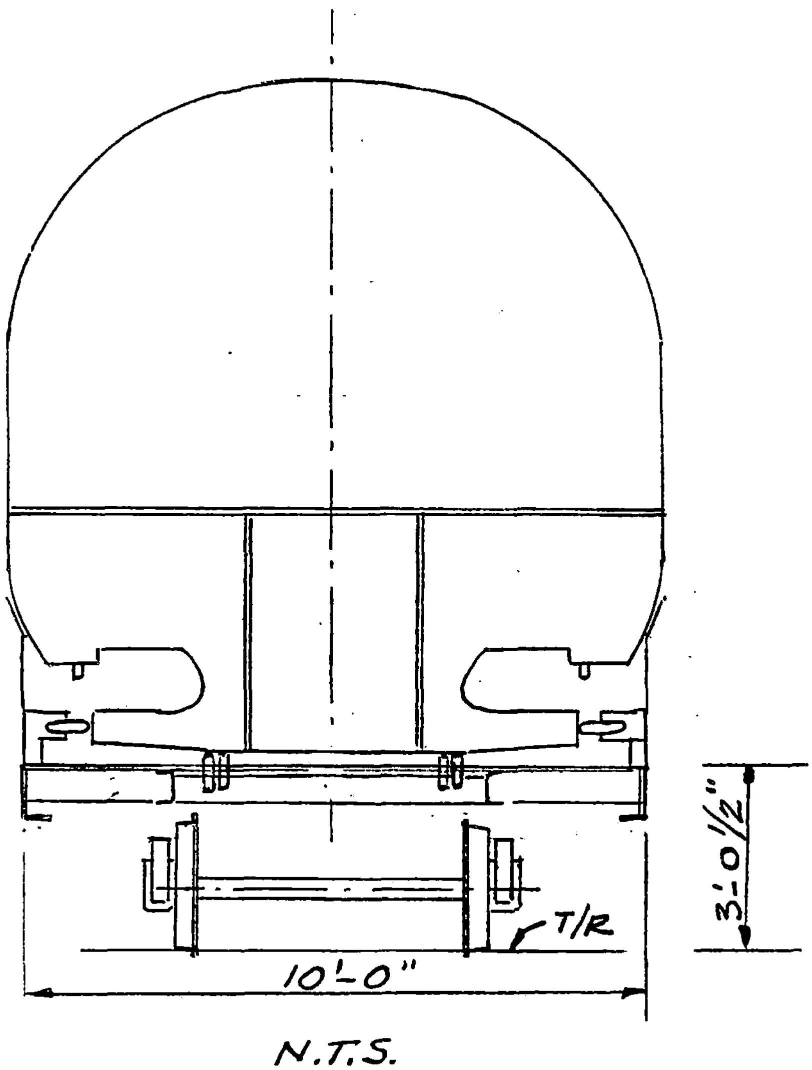


FIGURE 5-7
MAGLEV / RAIL CAR CARRIER
END VIEW

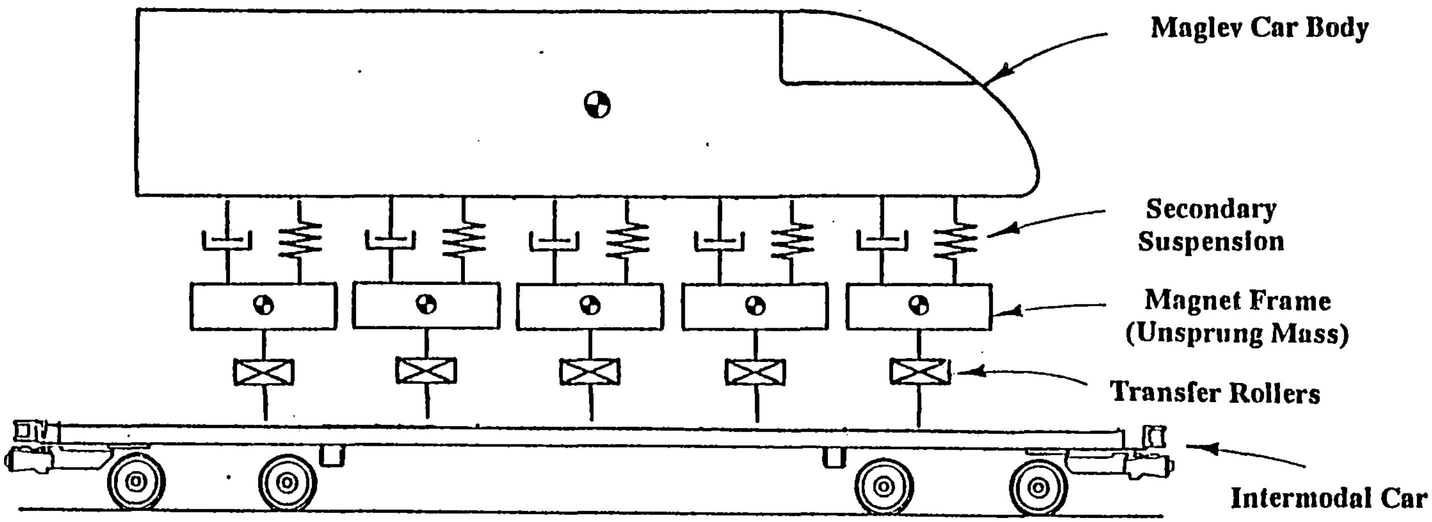


FIGURE 5-8

Sketch of Maglev Vehicle/Intermodal Car Model.

intermodal car secondary suspension consisting of air bags and hydraulic dampers was chosen to provide a reasonable ride quality.

An analysis of maglev vehicle ride quality was conducted using the maglev vehicle parameters for the HSST-300 end-car and mid-car vehicles as shown on Tables 5-1 and 5-2, and for the corresponding intermodal cars on Tables 5-3 and 5-4. The computer simulation was modified to include the fifth magnet support frame of the HSST-300 design (see Figure 5-8). Track and input geometry parameters are given in Table 5-5. Preliminary analysis with a TOFC/COFC flatcar with standard freight car trucks showed a somewhat harsh ride at the maglev passenger compartment. A vertical natural frequency of 1.4 Hz fully loaded (2.2 Hz for the empty car) with 22 percent of critical damping was chosen. An intermodal car body vertical bending mode of 3.7 Hz also was included in the analysis.

This harsh ride of the maglev vehicle was ameliorated somewhat by the use of a premium truck. A premium truck has a lower natural frequency (1.2-1.3 Hz) when compared with the standard freight car truck (1.4 Hz). One anticipated problem with the softer intermodal car suspension is the vertical deflection under the maglev vehicle as it is loaded or unloaded. A total deflection of 73 mm (2.89 in.) from the maglev guideway datum would occur unless some type of self-leveling action were provided. In its final design, this suspension would have to provide a compromise between good curving action and higher-speed "truck hunting" stability.

Results of the analysis are summarized in Tables 5-6 and 5-7 for the HSST-300 end-car and mid-car vehicles, respectively. Three different ride quality criteria are used for vertical or lateral ride comfort:

- the PEPLAR ride comfort index;
- the NASA ride comfort (DISC) index; and
- the German Railways (Deutsche Bundesbahn) W_z index.

TABLE 5-1

PARAMETERS REPRESENTING EMS-TYPE (HSST 300 END-CAR) MAGLEV VEHICLE.

MAGLEV CAR BODY MASS, MC1	=	23350. KG
UNSPRUNG MASS (PER FRAME), MUNS	=	1280. KG
MAGLEV CAR MASS MOMENT IN PITCH, PJC1	=	.9730E+06 KG-M**2
MAGLEV CAR MASS MOMENT IN ROLL, RJC1	=	.4167E+05 KG-M**2
MAGLEV CAR MASS MOMENT IN YAW, YJC1	=	.9670E+06 KG-M**2
MAGLEV UNSPRUNG MASS MOMENT IN ROLL, RJUNS	=	.1070E+04 KG-M**2
ROLLER TIRES (P[ER AXLE) VERTICAL STIFFNESS, KZE	=	.7000E+06 N/M,
SECONDARY SUSP. VERT. STIFFNESS (PER FRAME), KZS	=	.1860E+06 N/M
MAGLEV LEVITATION MAGNET DAMPING, CZE	=	.1400E+04 N-SEC/M
SECONDARY SUSPENSION DAMPING (PER FRAME), CZS	=	.1480E+05 N/M
ROLLER TIRES (PER AXLE) LATERAL STIFFNESS, KYE	=	.4700E+06 N/M,
SECONDARY SUSPENSION LAT. STIFF. (PER FRAME), KYS	=	.9300E+05 N/M
ROLLER TIRES (PER AXLE) LATERAL DAMPING, CYE	=	.1150E+04 N-S/M,
SECONDARY SUSP. LAT. DAMPING (PER FRAME), CYS	=	.1050E+05 N-S/M
ROLLER TIRES AVE. LATERAL, FROM C-LINE, AKE	=	0.546 M
VERTICAL SUSPENSION LATERAL, FROM C-LINE, AKS	=	1.190 M
CAR OVERALL LENGTH, LOV1	=	22.00 M
FRONT END OF CAR TO C.G., LCG1	=	11.00 M
ROLLER TIRE SETS (AXLES) CENTER-TO-CENTER, LMAG	=	0.79 M
DISTANCE FORWARD, CAR CG TO FRAME 1	=	6.90 M
DISTANCE FORWARD, CAR CG TO FRAME 2	=	2.95 M
DISTANCE FORWARD, CAR CG TO FRAME 3	=	-1.00 M
DISTANCE FORWARD, CAR CG TO FRAME 4	=	-4.95 M
DISTANCE FORWARD, CAR CG TO FRAME 5	=	-8.90 M
HEIGHT, CAR C.G. TO MAGLEV VEHICLE C.G., HMC1	=	2.000 M
HEIGHT, CAR C.G. TO 2nd SUSPENSION, HS	=	1.050 M
HEIGHT, CAR C.G. TO MAGLEV UNSPRUNG C.G., HU	=	.750 M
HEIGHT, CAR C.G. TO ROLLER TIRE TOPS, HE	=	.165 M
CAR BODY FIRST BENDING MODE NATURAL FREQ., FNC1	=	6.5 HZ
CAR BODY FIRST BENDING MODE DAMPING RATIO, ZETC1	=	.0200
NUMBER OF ROLLER TIRE SETS PER FRAME	=	5

TABLE 5-2

PARAMETERS REPRESENTING EMS-TYPE (HSST 300 MID-CAR) MAGLEV VEHICLE.

MAGLEV CAR BODY MASS, MC1	=	23350. KG
UNSPRUNG MASS (PER FRAME), MUNS	=	1280. KG
MAGLEV CAR MASS MOMENT IN PITCH, PJC1	=	.8080E+06 KG-M**2
MAGLEV CAR MASS MOMENT IN ROLL, RJC1	=	.4167E+05 KG-M**2
MAGLEV CAR MASS MOMENT IN YAW, YJC1	=	.8020E+06 KG-M**2
MAGLEV UNSPRUNG MASS MOMENT IN ROLL, RJUNS	=	.1070E+04 KG-M**2
ROLLER TIRES (P[ER AXLE) VERTICAL STIFFNESS, KZE	=	.7000E+06 N/M,
SECONDARY SUSP. VERT. STIFFNESS (PER FRAME), KZS	=	.1860E+06 N/M
MAGLEV LEVITATION MAGNET DAMPING, CZE	=	.1400E+04 N-SEC/M
SECONDARY SUSPENSION DAMPING (PER FRAME), CZS	=	.1480E+05 N/M
ROLLER TIRES (PER AXLE) LATERAL STIFFNESS, KYE	=	.4700E+06 N/M,
SECONDARY SUSPENSION LAT. STIFF. (PER FRAME), KYS	=	.9300E+05 N/M
ROLLER TIRES (PER AXLE) LATERAL DAMPING, CYE	=	.1150E+04 N-S/M,
SECONDARY SUSP. LAT. DAMPING (PER FRAME), CYS	=	.1050E+05 N-S/M
ROLLER TIRES AVE. LATERAL, FROM C-LINE, AKE	=	0.546 M
VERTICAL SUSPENSION LATERAL, FROM C-LINE, AKS	=	1.190 M
CAR OVERALL LENGTH, LOV1	=	20.00 M
FRONT END OF CAR TO C.G., LCG1	=	10.00 M
ROLLER TIRE SETS (AXLES) CENTER-TO-CENTER, LMAG	=	0.79 M
DISTANCE FORWARD, CAR CG TO FRAME 1	=	7.90 M
DISTANCE FORWARD, CAR CG TO FRAME 2	=	3.95 M
DISTANCE FORWARD, CAR CG TO FRAME 3	=	0.00 M
DISTANCE FORWARD, CAR CG TO FRAME 4	=	-3.95 M
DISTANCE FORWARD, CAR CG TO FRAME 5	=	-7.90 M
HEIGHT, CAR C.G. TO MAGLEV VEHICLE C.G., HMC1	=	2.000 M
HEIGHT, CAR C.G. TO 2nd SUSPENSION, HS	=	1.050 M
HEIGHT, CAR C.G. TO MAGLEV UNSPRUNG C.G., HU	=	.750 M
HEIGHT, CAR C.G. TO ROLLER TIRE TOPS, HE	=	.165 M
CAR BODY FIRST BENDING MODE NATURAL FREQ., FNC1	=	8.0 HZ
CAR BODY FIRST BENDING MODE DAMPING RATIO, ZETC1	=	.0200
NUMBER OF ROLLER TIRE SETS PER FRAME	=	5

TABLE 5-3

INTERMODAL CAR PARAMETERS USED WITH HSST 300 END-CAR MAGLEV VEHICLE.

CAR BODY MASS, MCAR	=	16940.	KG
TRUCK FRAME/BOLSTER MASS, MTF	=	1500.	KG
SIDE FRAME/EQUALIZER BEAM MASS,MSF	=	600.	KG
AXLE, BRAKE DISK, ETC., WAXL	=	950.	KG
CAR BODY MASS MOMENT IN PITCH, PJC2	=	.7613E+06	KG-M**2
CAR BODY MASS MOMENT IN ROLL, RJC2	=	.1410E+05	KG-M**2
CAR BODY MASS MOMENT IN YAW, YJC2	=	.7740E+06	KG-M**2
TRUCK FRAME MASS MOMENT IN PITCH, PJTF	=	.5000E+03	KG-M**2
TRUCK FRAME MASS MOMENT IN ROLL, RJTF	=	.1125E+04	KG-M**2
TRUCK FRAME MASS MOMENT IN YAW, YJTF	=	.6600E+03	KG-M**2
WHEELSET MASS MOMENT IN ROLL, RJA	=	.3400E+03	KG-M**2
VERTICAL PRIMARY SUSP. STIFFNESS, PER TRUCK, KZ1	=	.1200E+09	N/M
VERT. SECONDARY SUSP. STIFFNESS, PER TRUCK, KZ2	=	.1560E+07	N/M
LATERAL PRIMARY SUSP. STIFFNESS, PER TRUCK, KY1	=	.7200E+08	N/M
LAT. SECONDARY SUSP. STIFFNESS, PER TRUCK, KY2	=	.1040E+07	N/M
PRIMARY SUSP. YAW STIFFNESS, PER TRUCK, KPSI1	=	.1000E+06	N-M/RAD
PRIMARY SUSP. RACKING STIFFNESS, PER TRUCK, KRACK	=	.1000E+06	N-M/RAD
VERTICAL PRIMARY SUSP. DAMPING, PER TRUCK, CZ1	=	.1750E+06	N-S/M
VERT. SECONDARY SUSP. DAMPING, PER TRUCK, CZ2	=	.7660E+05	N-S/M
LATERAL PRIMARY SUSP. DAMPING, PER TRUCK, CY1	=	.1000E+06	N-S/M
LATERAL SECONDARY SUSP.DAMPING, PER TRUCK, CY2	=	.6250E+05	N-S/M
PRIMARY SUSPENSION YAW DAMPING, PER TRUCK, CPSI1	=	.1000E+04	N-M-S/RAD
PRIMARY SUSP. RACKING DAMPING, PER TRUCK, CRACK	=	.1000E+04	N-M-S/RAD
TRUCK C-LINE TO WHEEL/RAIL CONTACT, AW1	=	.756	M
TRUCK CENTERLINE TO PRIMARY SUSPENSION, AK1	=	1.000	M
TRUCK C-LINE TO SECONDARY SPRINGS, AK2	=	1.154	M
TRUCK CENTERLINE TO PRIMARY DAMPING, AC1	=	1.000	M
TRUCK CENTERLINE TO SECONDARY DAMPING, AC2	=	1.105	M
OVERALL LENGTH OF INTERMODAL CAR, LOV2	=	23.220	M
FRONT OF INTERMODAL CAR TO MAGLEV CAR C.G., LCG1P	=	12.220	M
LEAD TRUCK CENTER TO CAR BODY C.G., LCG2	=	11.610	M
TRUCK CENTER SPACING, LTRK	=	15.910	M
TRUCK AXLE SPACING, LAXL	=	1.727	M
HEIGHT, RAIL TO WHEELSET C.G., HA	=	.305	M
HEIGHT, RAIL TO PRIMARY SUSPENSION, HK1	=	.305	M
HEIGHT, RAIL TO TRUCK FRAME C.G., HTF	=	.425	M
HEIGHT, RAIL TO SECONDARY SUSPENSION, HK2	=	.800	M
HEIGHT, RAIL TO CAR BODY C.G., HMC2	=	.750	M
INTERMODAL CAR BODY BENDING FREQUENCY, FNC2	=	3.7	HZ
BODY BENDING DAMPING RATIO, ZETC2	=	.020	

TABLE 5-4

INTERMODAL CAR PARAMETERS USED WITH HSST 300 MID-CAR MAGLEV VEHICLE.

CAR BODY MASS, MCAR	=	14680. KG
TRUCK FRAME/BOLSTER MASS, MTF	=	1500. KG
SIDE FRAME/EQUALIZER BEAM MASS,MSF	=	600. KG
AXLE, BRAKE DISK, ETC., WAXL	=	950. KG
CAR BODY MASS MOMENT IN PITCH, PJC2	=	.4892E+06 KG-M**2
CAR BODY MASS MOMENT IN ROLL, RJC2	=	.1220E+05 KG-M**2
CAR BODY MASS MOMENT IN YAW, YJC2	=	.5010E+06 KG-M**2
TRUCK FRAME MASS MOMENT IN PITCH, PJTF	=	.5000E+03 KG-M**2
TRUCK FRAME MASS MOMENT IN ROLL, RJTF	=	.1125E+04 KG-M**2
TRUCK FRAME MASS MOMENT IN YAW, YJTF	=	.6600E+03 KG-M**2
WHEELSET MASS MOMENT IN ROLL, RJA	=	.3400E+03 KG-M**2
VERTICAL PRIMARY SUSP. STIFFNESS, PER TRUCK, KZ1	=	.1200E+09 N/M
VERT. SECONDARY SUSP. STIFFNESS, PER TRUCK, KZ2	=	.1490E+07 N/M
LATERAL PRIMARY SUSP. STIFFNESS, PER TRUCK, KY1	=	.7200E+08 N/M
LAT. SECONDARY SUSP. STIFFNESS, PER TRUCK, KY2	=	.9920E+06 N/M
PRIMARY SUSP. YAW STIFFNESS, PER TRUCK, KPSI1	=	.1000E+06 N-M/RAD
PRIMARY SUSP. RACKING STIFFNESS, PER TRUCK, KRACK	=	.1000E+06 N-M/RAD
VERTICAL PRIMARY SUSP. DAMPING, PER TRUCK, CZ1	=	.1750E+06 N-S/M
VERT. SECONDARY SUSP. DAMPING, PER TRUCK, CZ2	=	.7290E+05 N-S/M
LATERAL PRIMARY SUSP. DAMPING, PER TRUCK, CY1	=	.1000E+06 N-S/M
LATERAL SECONDARY SUSP.DAMPING, PER TRUCK, CY2	=	.5950E+05 N-S/M
PRIMARY SUSPENSION YAW DAMPING, PER TRUCK, CPSI1	=	.1000E+04 N-M-S/RAD
PRIMARY SUSP. RACKING DAMPING, PER TRUCK, CRACK	=	.1000E+04 N-M-S/RAD
TRUCK C-LINE TO WHEEL/RAIL CONTACT, AW1	=	.756 M
TRUCK CENTERLINE TO PRIMARY SUSPENSION, AK1	=	1.000 M
TRUCK C-LINE TO SECONDARY SPRINGS, AK2	=	1.154 M
TRUCK CENTERLINE TO PRIMARY DAMPING, AC1	=	1.000 M
TRUCK CENTERLINE TO SECONDARY DAMPING, AC2	=	1.105 M
OVERALL LENGTH OF INTERMODAL CAR, LOV2	=	20.000 M
FRONT OF INTERMODAL CAR TO MAGLEV CAR C.G., LCG1P	=	10.000 M
LEAD TRUCK CENTER TO CAR BODY C.G., LCG2	=	10.000 M
TRUCK CENTER SPACING, LTRK	=	13.900 M
TRUCK AXLE SPACING, LAXL	=	1.727 M
HEIGHT, RAIL TO WHEELSET C.G., HA	=	.305 M
HEIGHT, RAIL TO PRIMARY SUSPENSION, HK1	=	.305 M
HEIGHT, RAIL TO TRUCK FRAME C.G., HTF	=	.425 M
HEIGHT, RAIL TO SECONDARY SUSPENSION, HK2	=	.800 M
HEIGHT, RAIL TO CAR BODY C.G., HMC2	=	.750 M
INTERMODAL CAR BODY BENDING FREQUENCY, FNC2	=	5.0 HZ
BODY BENDING DAMPING RATIO, ZETC2	=	.020

TABLE 5-5

TRACK PARAMETERS AND TRACK GEOMETRY RANDOM POWER SPECTRA.

WHEEL/RAIL AND TRACK PARAMETERS, PER WHEEL --

TRACK VERTICAL STIFFNESS, KZR	= .7000E+08 N/M
TRACK VERTICAL DAMPING, CZR	= .4380E+05 N-S/M
RAIL/TIE EFFECTIVE MASS, MRP	= 891.3 kG
TRACK VERTICAL MODULUS, UTRK	= .3450E+08 N/M/M
RAIL LENGTH, LR	= 11.890 M
TRACK LATERAL STIFFNESS, KL	= .1750E+08 N/M
TRACK LATERAL DAMPING, CL	= .3450E+05 N-S/M
WHEEL/RAIL LONG. CREEP COEFF., F11	= .4500E+07 N
WHEEL/RAIL LAT. CREEP COEFF., F22	= .4000E+07 N
WHEEL/RAIL SPIN/LAT. CREEP COEFF., F23	= .7900E+04 N-M
NOMINAL FLANGE CLEARANCE, DLYFLG	= .009 M
AVERAGE WHEEL CONICITY, LAM	= .050

TRACK RANDOM GEOMETRY PARAMETERS --

	CON1	CON2	N1	N2	WVLL	BSPEC
SURFACE	.3861E-05	.1869E-07	.910	3.590	7.3	20.0
ALIGNMENT	.2763E-07	.7137E-08	2.620	3.150	12.7	20.0
CROSS LEVEL	.6954E-05	.4829E-07	.810	2.520	18.3	20.0

FIRST 16 SPECTRAL COMPONENTS OF RAIL LENGTH --

SURFACE --

.1392E-03	.8299E-04	.4719E-05	.2104E-05	.3657E-06	.6076E-06
.1599E-06	.3500E-06	.4306E-06	.3933E-06	.1835E-06	.9851E-07
.0000E+00	.0000E+00	.0000E+00	.0000E+00		

ALIGNMENT --

.4916E-04	.4916E-05	.7865E-06	.3146E-06	.0000E+00	.0000E+00
.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
.0000E+00	.0000E+00	.0000E+00	.0000E+00		

CROSS LEVEL --

.1599E-03	.8199E-04	.1105E-04	.1105E-05	.1834E-05	.3932E-06
.5053E-06	.2654E-06	.1105E-05	.2654E-06	.2969E-06	.6980E-07
.0000E+00	.0000E+00	.0000E+00	.0000E+00		

TABLE 5-6

Ride Quality Assessment of EMS-Type HSST 300 End-Car on Premium-Truck Intermodal Flatcar, Good BJR Track.

End Car	Ride Quality Indices			
Speed (kph)	PEPLAR	NASA DISC	W_z (vert.)	W_z (lat.)
50	1.51	1.07	2.13	1.77
75	1.61	1.36	2.14	2.12
100	1.65	1.51	2.18	2.24
125	1.70	1.82	2.29	2.27
150	1.84	2.29	2.50	2.35

Note: 150(f) denotes 150 kph with hard wheel/rail flange contact.

TABLE 5-7

Ride Quality Assessment of EMS-Type HSST 300 Mid-Car on Premium-Truck Intermodal Flatcar, Good BJR Track.

Mid Car	Ride Quality Indices			
Speed (kph)	PEPLAR	NASA DISC	W_z (vert.)	W_z (lat.)
50	1.41	0.84	2.11	1.45
75	1.51	1.09	2.22	1.77
100	1.56	1.44	2.24	1.98
125	1.63	1.62	2.27	2.12
150	1.73	1.91	2.36	2.26

Ride Quality Ratings:

Wz	Condition of Ride
1	"Excellent"
2	"Good"
3	"Satisfactory"
4	"Car in Working Order"
5	"Dangerous"

Peplar	Comfort Scale
1	Very comfortable
2	Comfortable
3	Somewhat comfortable
4	Neutral
5	Somewhat uncomfortable
6	Uncomfortable
7	Very uncomfortable

NASA DISC from 1 to 6, where 6 = "High degree of discomfort".

There is rather good agreement among the three indices. Based on the model, the ride quality is predicted to be "good" or "comfortable" on bolted jointed rail (BJR) track geometry typical of commuter rail lines, and quite acceptable for the limited travel time expected between the interchange point and the center-city terminus. The ride quality would be improved somewhat with the use of continuous welded rail (CWR) track geometry.

5.7 Conclusions

As a result of this analysis, it appears feasible that a maglev train could transfer onto a rail carrier within a time span of 4 to 5 minutes. This modal transfer time must be factored into the remaining travel time to develop a total travel time between center cities, and its reasonableness must be tested against other high speed transportation modes (i.e., high-speed rail).

The rail car carriers would have to be designed to accommodate the specific maglev technology that is chosen - no "off the shelf" railroad equipment would meet the unique requirements of this mode without major modifications. However, much of the existing railroad technology can be adapted for use on the maglev/rail car carriers.

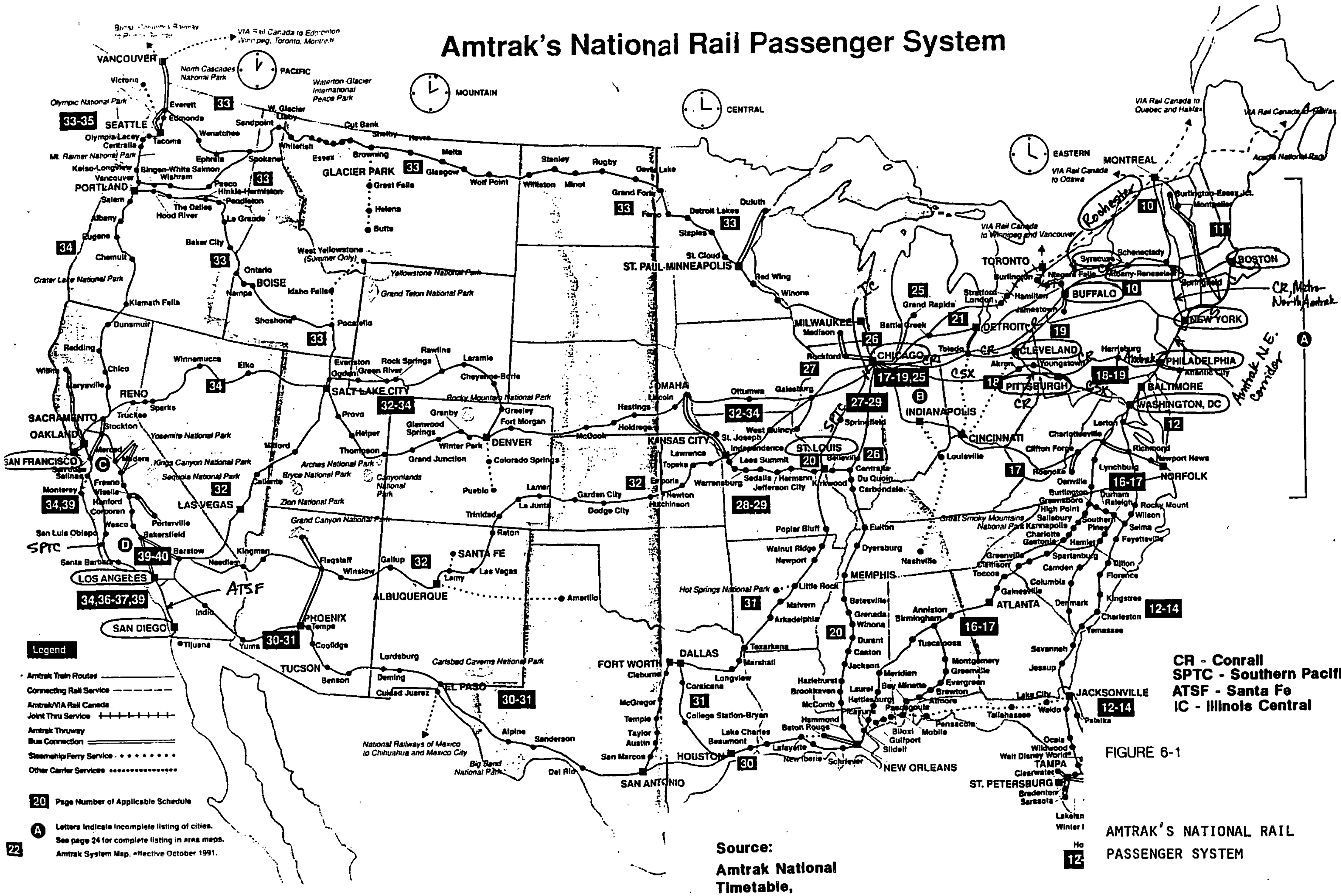
If this intermodal concept is furthered as a means of accelerating the implementation of maglev technology in the United States, precluding the need for construction of maglev guideways in the center cities in the near future, additional engineering work will be necessary. This further work would define:

- the scope of work for the design, construction and testing of a prototypical maglev / rail car carrier;
- a schedule for program implementation; and
- a budget for design, construction and testing.

6.0 URBAN TERMINAL AND CORRIDOR CHARACTERISTICS

In order to assess the feasibility of maglev systems accessing existing urban transportation terminals in the United States, information on fifteen (15) selected cities was gathered and reviewed. These cities are located on some of the most heavily traveled corridors in the nation and are circled on the attached Figure 6-1, Amtrak's National Rail Passenger System map. Information reviewed included miscellaneous reports and studies, railroad valuation maps (showing track plans, right-of-way holdings, terminal layouts, turnout information, adjacent land uses, etc.), United States Geological Survey (USGS) 7.5 minute topographic maps, track charts, photographs, typical cross-sections, periodicals, and technical magazines. (A list of this information is provided in Appendix E, as well as in the References.) At the same time, telephone conversations were initiated with Federal, State and local officials regarding present and future transportation improvement plans for the individual metropolitan areas. Special attention was paid to the following:

- the presence and location of existing transportation terminals and their effectiveness in serving the needs of the individual metropolitan area;
- the physical characteristics of the transportation corridors which serve those terminals;
- characteristics of adjacent land uses, and any proposed modifications;
- plans for major capital investment in transportation facilities (e.g., transit systems, multimodal facilities, major rehabilitation, etc.);
- restrictive horizontal and vertical clearances;
- horizontal curve radii;
- length and height of existing station platforms and the presence of platform gaps;
- characteristics of current operating equipment;



CR - Conrail
SPTC - Southern Pacific
ATSF - Santa Fe
IC - Illinois Central

FIGURE 6-1

AMTRAK'S NATIONAL RAIL PASSENGER SYSTEM

N.T.S.

Source:
Amtrak National Timetable, Fall/Winter 1991/1992

- presence of electrification and power pickup arrangements, if applicable; and

- present and future interfaces with other transportation modes.

At the same time, certain operational characteristics such as terminal and line ownership, existing traffic levels, timetables and other factors were evaluated as that information was made available.

Following is a discussion of the individual urban areas, a description of their existing transportation infrastructure and current and future transportation plans and an assessment of the feasibility of implementing maglev systems in these areas. Applicable plans, terminal drawings, sketches and other information are included where available.

6.1. San Francisco

Two transportation terminals exist in downtown San Francisco - the Transbay Terminal located on Mission Street between Beale and 2nd Streets, and the Caltrans Terminal at 4th and Townsend Streets. The Transbay Terminal is a major bus terminal which also serves as the Amtrak Station for rail passengers who make a connecting bus transfer from the main Amtrak station in Oakland. Amtrak offers the only direct intercity rail service into San Francisco today, travelling along the peninsula to San Jose and continuing on to Gilroy, 126 km (79 miles) to the southeast. The number of daily trains on this Caltrans route was increased from 54 to 60 trains in July 1992. However, the Caltrans terminal at 4th and Townsend Streets is located seven blocks from Market Street, the main downtown street which contains the Bay Area Rapid Transit (BART) and San Francisco Municipal Railway (MUNI) subway, and is nearly 1.6 km (one mile) from the city's central business district (CBD).

The Caltrans Terminal was operated by the California Department of Transportation, which took over commuter rail service from the Southern Pacific Transportation Company (SPTC) in 1980; however, Amtrak assumed commuter rail operation in July of this year. The Caltrans Terminal is owned by Amtrak, and contains 11 stub-ended tracks. A total of six low-level platforms serve these 11 tracks, ranging in length from 198 meters (650 feet) to 256 meters (840 feet). (See Figure 6-2.) The platforms are continuous and there is no electrification. A complex system of turnouts on the west side allows access to the terminal from the 2-track mainline to San Jose / Gilroy that parallels the San Francisco Bay.

Corridor Characteristics

The SPTC Bayshore line parallels the west shore of the San Francisco Bay through San Jose and down into the agriculturally-rich San Joachin Valley. Commuter rail service (i.e., CalTrain) is operated from the 4th and Townsend Terminal to Gilroy. The 2-track mainline was recently purchased by the State from the SPTC for $230 million, and has a maximum degree of curvature of 10° 50' as it turns south to San Jose from the CalTrain terminal. The main line tracks in the city are grade-separated for the most part, with a mixture of both underpasses and overpasses, along with a few grade crossings. This corridor also contains the four (4) tunnels listed below:

- Tunnel #1 - 554 meters (1,817.3 feet) long, located south of Mariposa Street
- Tunnel #2 - 331 meters (1,087.4 feet) long, located south of 23rd Street
- Tunnel #3 - 721 meters (2,364.0 feet) long, located south of Oakdale Street
- Tunnel #4 - 1,081 meters (3,547.0 feet) long, located south of Paul Avenue.

These tunnels have sufficient clearance for both single-level and bi-level commuter rail equipment, as shown on Figure 6-3. South of Tunnel #4 is the site of SPTC's Bayshore Yard site. This facility has not been used as an active transportation facility for some time, and is about 1.6 km (1 mile) southwest of Candlestick Park. South of the Bayshore Yard, the main tracks turn right along a 2°15' curvature around the San Bruno Mountains at Sierra Point. At this location, the mainline tracks were relocated and a 5th tunnel through the mountains was abandoned as part of the Bayshore Highway construction. The tracks at this point bisect the cities of South San Francisco and San Bruno, and pass less than 1.6 km (1 mile) from the San Francisco International Airport terminal. The Caltrans tracks south of the airport are well-situated within the numerous cities and suburbs along the South Bay area and are in close proximity to many of the area's activity centers (e.g. San Mateo County Fairgrounds, Bay Meadows Racetrack, Stanford University, San Jose International Airport, University of Santa Clara). The CalTrain service and the Santa Clara County Transportation Agency's light rail transit system interface at Tamien Station. A total of 24 commuter rail stations are located between San Francisco and San Jose (College Park), most with 183 meter (600-feet) long low-level platforms.

Future Plans

Because the CalTrain terminal at 4th and Townsend is nearly 1.6 km (one mile) from San Francisco's CBD, transportation planners have been studying ways of getting this commuter rail terminal closer to the CBD, and are completing an environmental impact statement for a 2.41 km (1.5-mile) extension that would move the terminal to a more central downtown location. Three options are being studied which would extend the existing tracks from just north of Tunnel No. 1 at Mariposa Street to an underground terminal located close to the city's central business district (see Figure 6-4). All three options would share portions of the same right-of-way, and have 304.8m (1000-foot) long platforms and 6-track terminals. They would also include an intermediate underground station in the Mission Bay Project area and a new yard facility located at Bayshore approximately 9.6 km (6 miles) south of the new terminal locations. The three options are:

- Alternative 4 - this alignment would use an 8-degree curve to transition into the King Street right-of-way where it would continue underground to a new Mission Bay subway station located at 4th and King Streets. The alignment would transition into Second Street via a 14-degree curve, and would end in a 2-level terminal located within the right-of-way of Second Street and connected to the BART/MUNI Montgomery Street Station through a shared mezzanine.

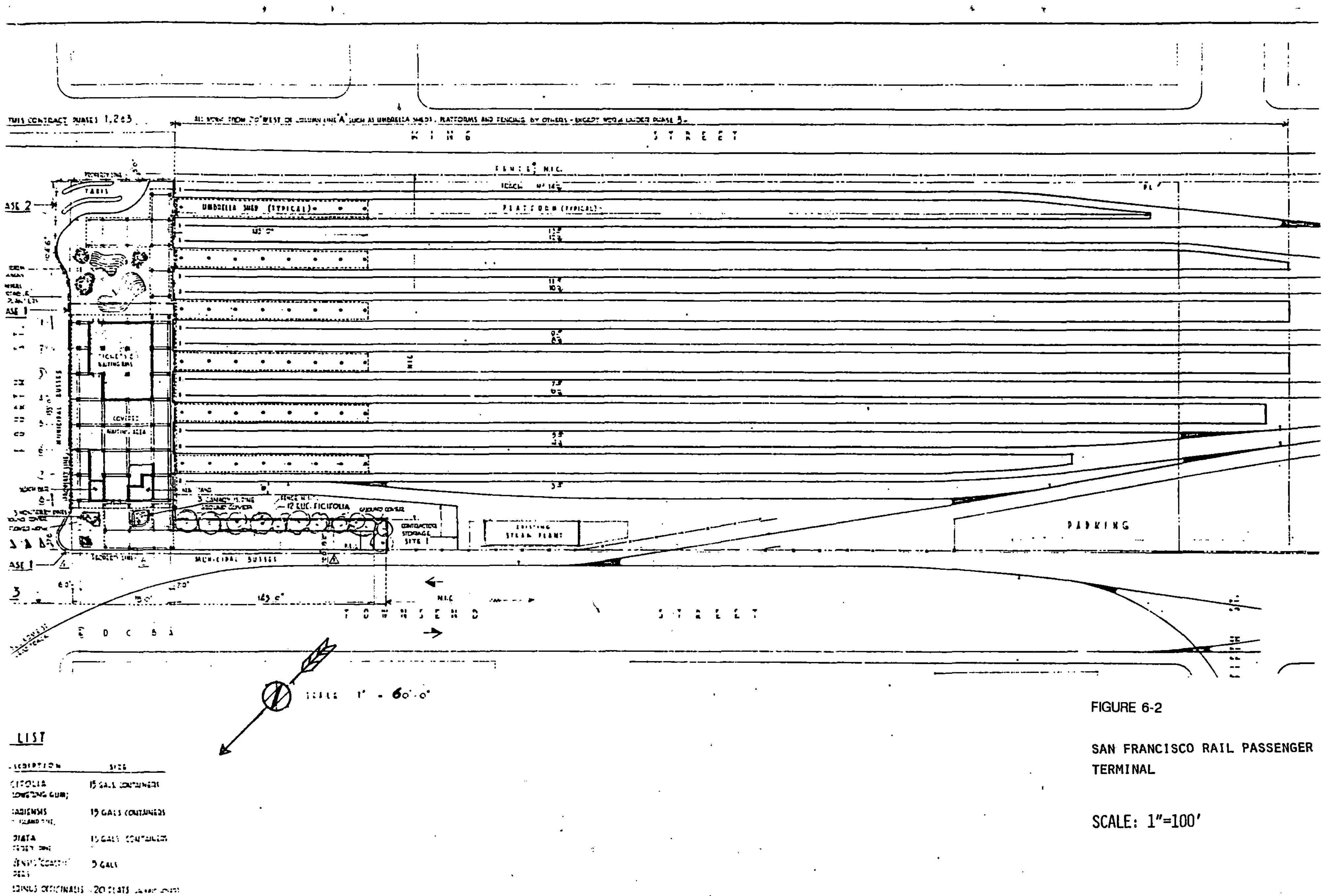
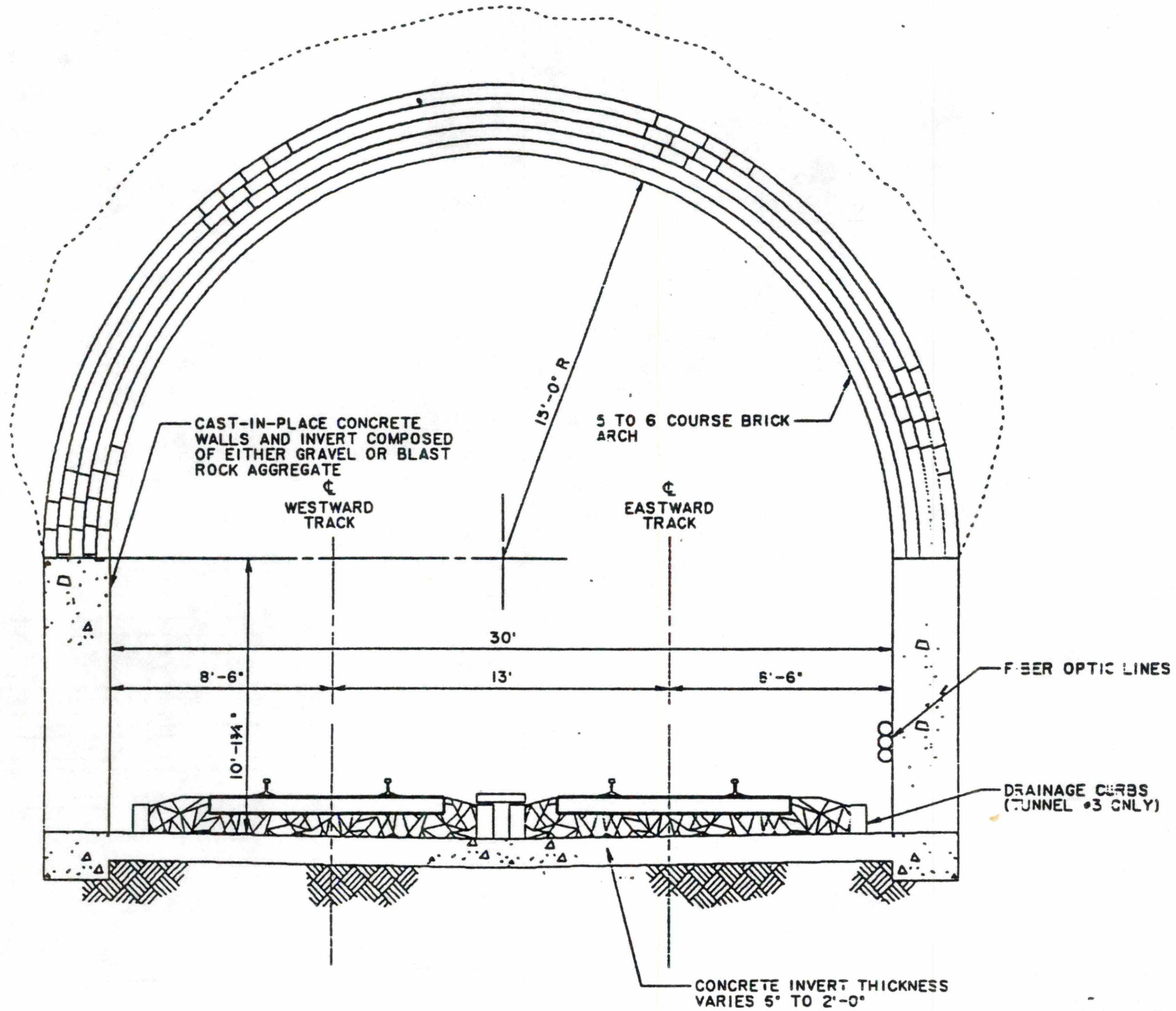


FIGURE 6-2

SAN FRANCISCO RAIL PASSENGER TERMINAL

SCALE: 1"=100'



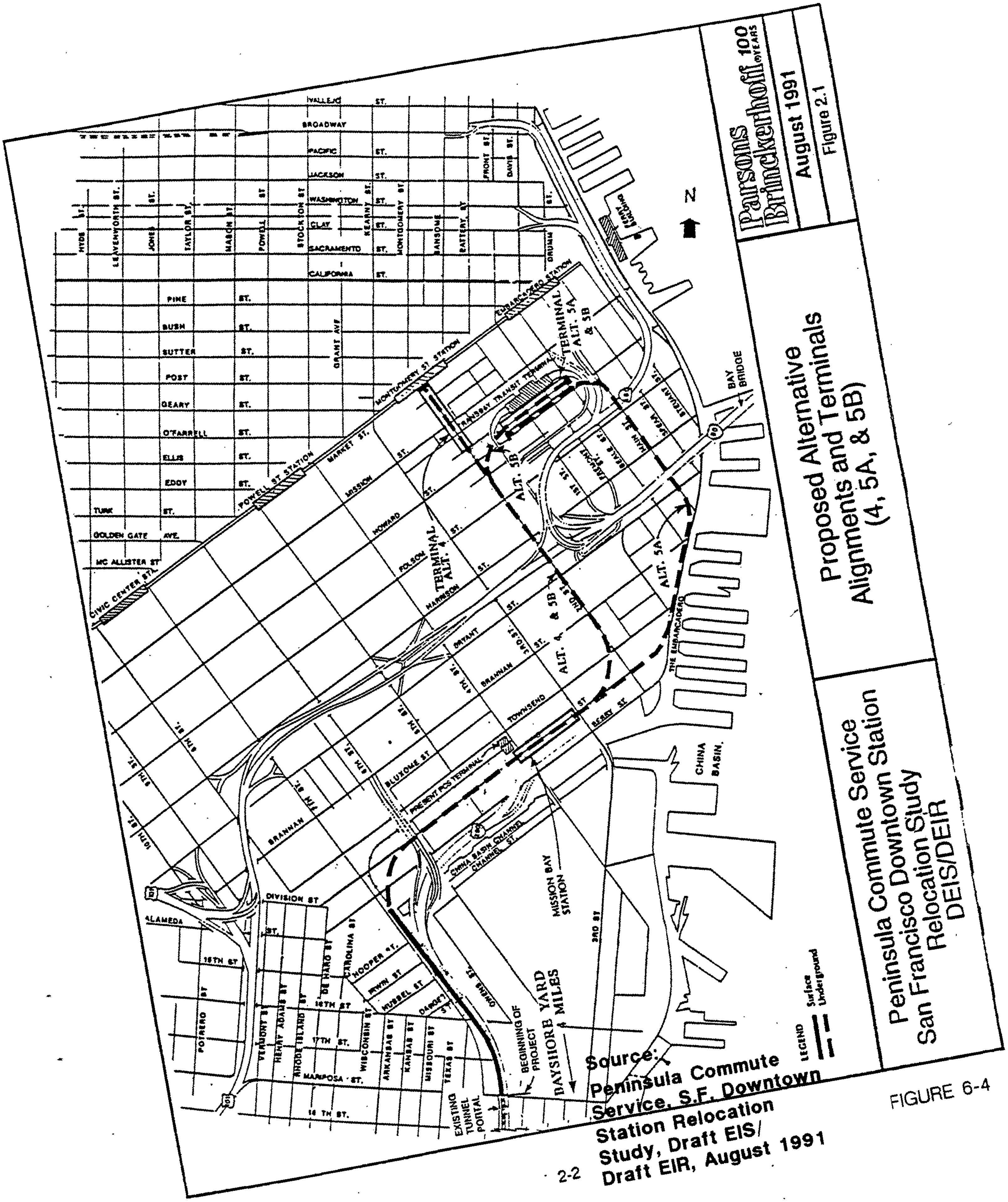
TYPICAL SECTION

FACING RR EAST
EXISTING TUNNEL & TRACK

FIGURE 6-3

TYPICAL SECTION OF 2 RAILROAD TUNNELS

SCALE: 1"=5'



Source: Peninsula Commute Service, S.F. Downtown Station Relocation Study, Draft EIS/ Draft EIR, August 1991

FIGURE 6-4

- Alternative 5A - this alignment is identical to Alternative 4 until Second Street where it would continue along King Street to the Embarcadero. This alignment would remain underground beneath the railroad tracks which parallel the Embarcadero and would turn again into the Main Street right-of-way. After proceeding under the freeway and bus ramps located east of the Transbay Terminal, the alignment would curve into the right-of-way between Howard and Natoma Streets, ending adjacent to and south of the Transbay Terminal just short of Second Street.

- Alternative 5B - this alignment is almost identical to the Alternative 4 alignment, utilizing the King Street and 2nd Street rights-of-way. Just north of the Folsom Street/2nd Street intersection, a series of No. 10 turnouts and 12-degree and 15-degree curves transitions the 2-track alignment into a 6-track terminal located adjacent to and south of the Transbay Terminal in the right-of-way between Howard and Natoma Streets, ending at Beale Street.

In Alternatives 5A and 5B, a 312.1m (1,024 feet) long pedestrian passageway is proposed under Fremont Street. Complete with escalators, elevators and moving sidewalks, the passageway would facilitate intermodal transfers between the proposed commuter rail-Amtrak terminal, the Transbay Terminal and the BART/MUNI Embarcadero Station. The estimated cost of these three station relocation alternatives ranges from $475 to $867 million, and the Environmental Impact Statement process is currently on hold.

MUNI plans an extension of its light rail transit (LRT) system from Embarcadero Station to the planned mixed use development at Mission Bay in 1997. This extension would run at-grade in an assumed King Street median and would serve the existing Fourth and Townsend Terminal as well as the planned Mission Bay subway station at 4th and King Streets, terminating at Sixth Street.

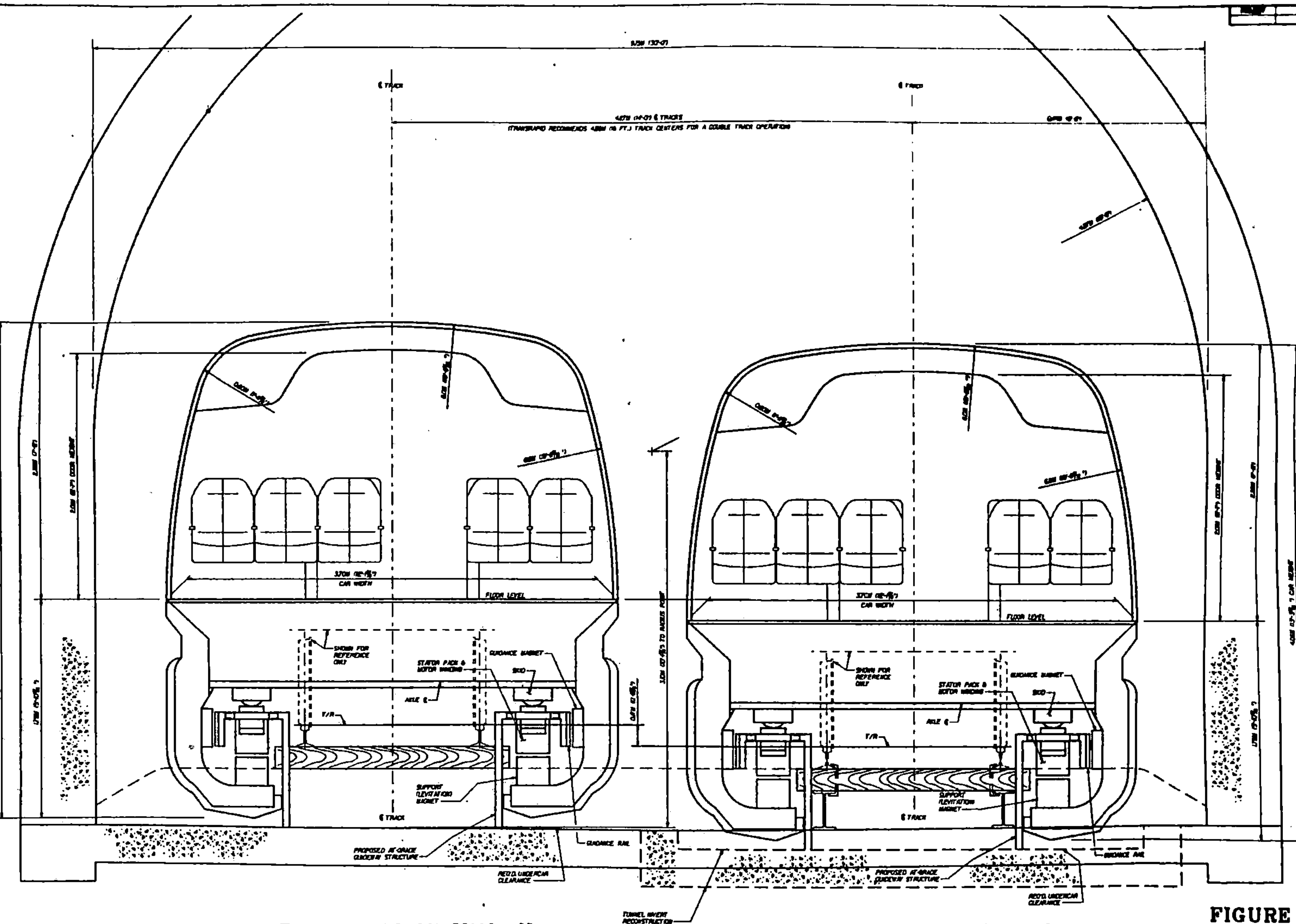
BART recently broke ground for a $139 million extension of the Daly City line to Colma as the first leg of an extension to the San Francisco International Airport. Possible alignment alternatives at the airport include a subway station under the central parking garage as well as a station located just west of the airport in the SPTC right-of-way.

In downtown San Jose, the CalTrain Cahill St. Station which serves CalTrain and Amtrak operations on the peninsula is undergoing a $5-million facelift. This station is across the street from the planned San Jose Arena and will connect with Santa Clara County Transportation Agency's (SCCTA) planned Vasona LRT Extension. The existing LRT system also interfaces with CalTrain at Tamien Station and SCCTA is planning a Tasman Corridor project that will interface with CalTrain again at Mountain View.

<u>Implementation Issues</u>

The corridor is well suited, for the most part, for the higher-speed maglev technology between the San Francisco/San Jose urban area. Much of the corridor in the higher density areas is grade-separated, with long tangent sections and relatively flat curvature (most in the 1 to 3 degree range). There are, however, numerous grade crossings in the lower-density South Bay suburban areas, which would require grade separation if high speed ground transportation is employed.

In order for the future maglev system to utilize the existing railroad corridor into downtown San Francisco, it would have to operate within the four tunnels previously discussed. One of the wider maglev systems (Transrapid) was superimposed upon the existing tunnel envelope in two scenarios to ascertain its impact upon the tunnel system. That investigation is shown graphically on Figure 6-5, and shows that one of the wider maglev systems available is able to successfully negotiate these significant civil works into the central San Francisco area. If no modifications are made to the existing tunnel invert, the top of rail on the dual-mode structure must be raised about 0.17m (6.69 in.). If this raising of the top of rail is unacceptable, then the tunnel must be lowered that amount to provide the proper undercar clearance on the "wrap-around" magnet configuration.



Transrapid 07 With No Tunnel Reconstruction - Railroad Profile Raised

Transrapid 07 With Tunnel Invert Reconstruction - No Change to Railroad Profile

FIGURE 6-5

ATLANTA GEORGIA

Maglev/ Railroad Tunnel Interface in San Francisco

DESIGN M. GILLAM	SCALE	DATE DEC. 1992	
DRAWN J. PARKS	CHECK	SHEET	OF

The BART Extension to the airport holds some interesting possibilities. Should the proposed terminal project not be pursued (because of cost or other considerations) or be deemed to be unacceptable for high speed application because of extremely constrictive curvature or other operational considerations, it may be possible to construct a high speed (maglev) / heavy rail transfer station at the airport. Feasibility of this transfer station would ultimately depend upon its final location and a host of organizational / institutional issues.

In its BAA report, Martin Marietta recommended that a Los Angeles - San Francisco maglev system use the Interstate Highway 5 and 580 rights-of-way to terminate in the East Bay area at San Leandro. At San Leandro, the maglev system would interface with the existing BART system. As an alternative, another route over the Call Mountains east of Salinas near Panoche Pass should be investigated. This possible alignment would provide access to the highly populated South Bay areas from Gilroy north, and may prove to be a more viable alternative.

6.2 Los Angeles

Description of Existing Transportation Terminals

The Los Angeles Union Passenger Terminal (LAUPT) is located on the northeast corner of Alameda and Aliso, and is owned by the Los Angeles Union Passenger Terminal Company. The terminal is served by Amtrak, the Union Pacific Railroad (UP), the Atchison, Topeka & Santa Fe Railway (ATSF) and the SPTC, and is capable of handling bi-level commuter rail equipment. LAUPT contains a total of 17 stub-ended tracks (4 have been removed) and 11 low-level platforms ranging in length from 152.4 meters (500 feet) to 317 meters (1,040 feet, as shown on Figure 6-6). Two of the platforms, 277 meters (910 feet) and 299 meters (980 feet) in length, presently serve no trackage. All platforms are accessed from a passenger subway and are continuous. There is presently no electrification of the tracks at LAUPT. A four track system feeds the terminal from the north, with a series of 9° 30' curves to the right providing access to the three railroads discussed above at an interlocking located above the Los Angeles River. Railroad trackage parallels the river on both sides in both directions from this river crossing area called Mission Junction. The minimum turnouts used for the interlockings are No. 10's.

The Southern California Rapid Transit District (SCRTD) bus system serves the terminal well, and the Red Line heavy rail system will interface with LAUPT through a newly-constructed subway station which is located under the yard area and very nearly perpendicular to it. The Los Angeles Region's proposed 640 km (400 mile) - 60 station commuter rail operation (Metrolink) will also utilize LAUPT as its hub operation, making this terminal very valuable from an intermodal framework. Metrolink began operation on October 26 with a total of 12 trains serving 10 commuter stations over a 182 km (114 mile) network reaching Moorpark to the northwest, Santa Clarita on the north and Pomona on the east. Patrons can transfer free to Metrolink shuttles which will travel throughout the downtown area, and will also be able to transfer free to the Red Line heavy rail system when it begins operation in March 1993. Other modes of transportation at the LAUPT include taxis and corporate shuttles.

Corridor Characteristics

As trains depart LAUPT for points north, the alignment on the corridor is rather circuitous. Mission Junction must be negotiated prior to entering the Southern Pacific Transportation Company (SPTC) right-of-way which is parallel to and just west of the Los Angeles River. Dodger Stadium is about 1.6 km (1 mile) to the west of the corridor in Elysian Park at this point. The Los Angeles County Transportation Commission (LACTC) recently bought the 107 km (67 mile) SPTC corridor from downtown to Palmdale for future Metrolink operation and both the Moorpark and Santa Clarita trains operate on portions of this right-of-way. This purchase provides additional access into LAUPT via another bridge over the Los Angeles River located between the Pasadena Freeway and Interstate 5 (the Golden State Freeway).

After crossing the river and passing under Interstate 5, the alignment passes an extensive Southern Pacific freight classification yard and begins to parallel San Fernando Road. The curves encountered along the corridor in this area are in the one to two degree range, relatively well suited for high speed operation. The railroad corridor passes to the west of Glendale's town center and bisects Burbank. The Hollywood-Burbank Airport is just west and south of the corridor at this point. As the mountains north of Los Angeles approach, a series of reverse curves takes the corridor under Interstate 5 near its intersection with Interstate 210 (Foothill Freeway), then parallels it over the mountains, past Six Flags Magic Mountain and out of the L.A. metropolitan area.

Future Plans

LACTC has embarked upon the most ambitious transportation improvement program in perhaps the world, planning to spend about $183 billion over the next 30 years to improve mobility in the Los Angeles metropolitan region (see Figure 6-7). This program includes integrated highway, bus, rail and transportation demand management elements and includes a future LRT line serving Glendale and Burbank, as well as a Blue Line LRT Extension to Pasadena. Access to Los Angeles International Airport will be provided via additional planned rail projects.

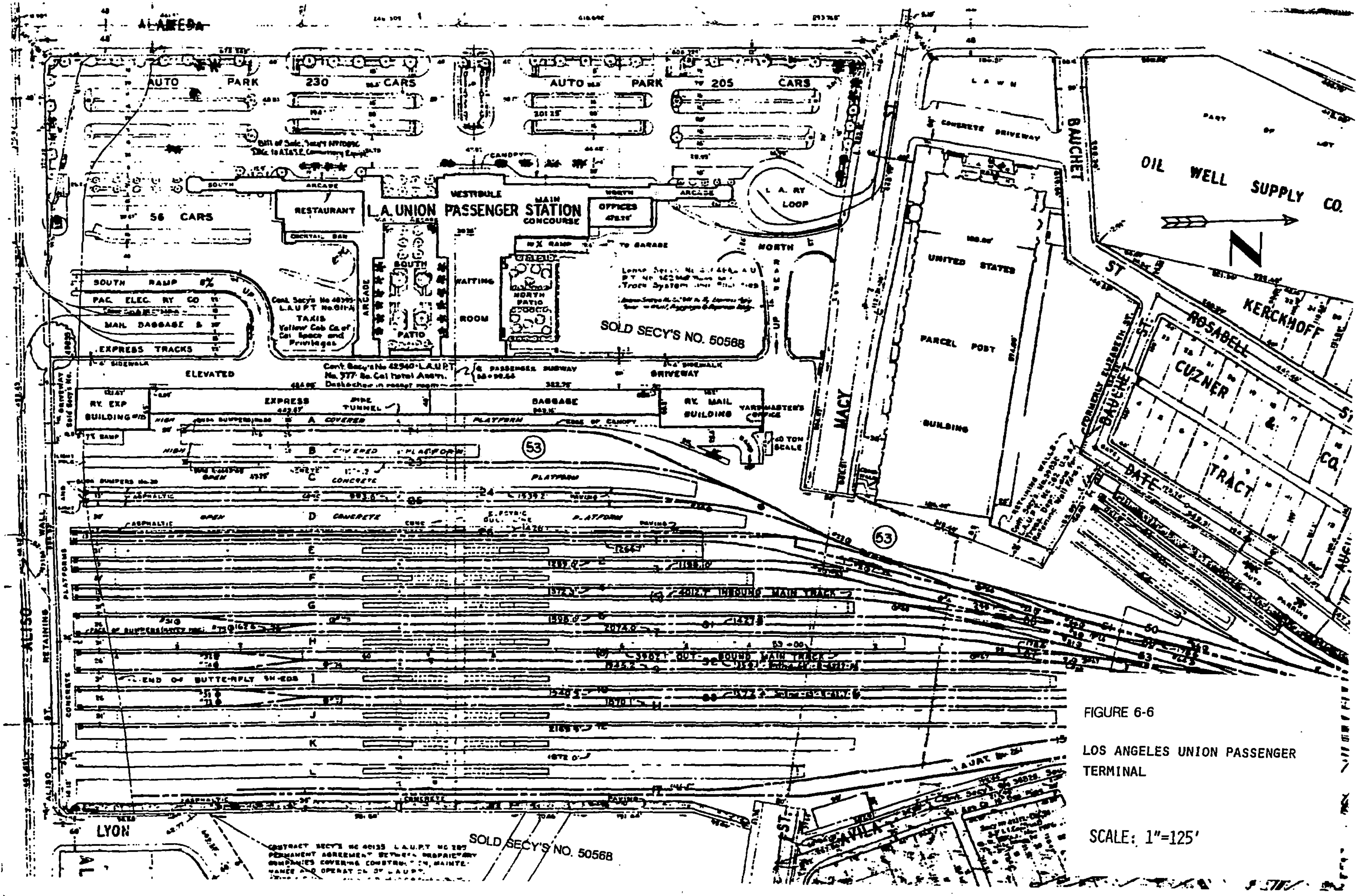
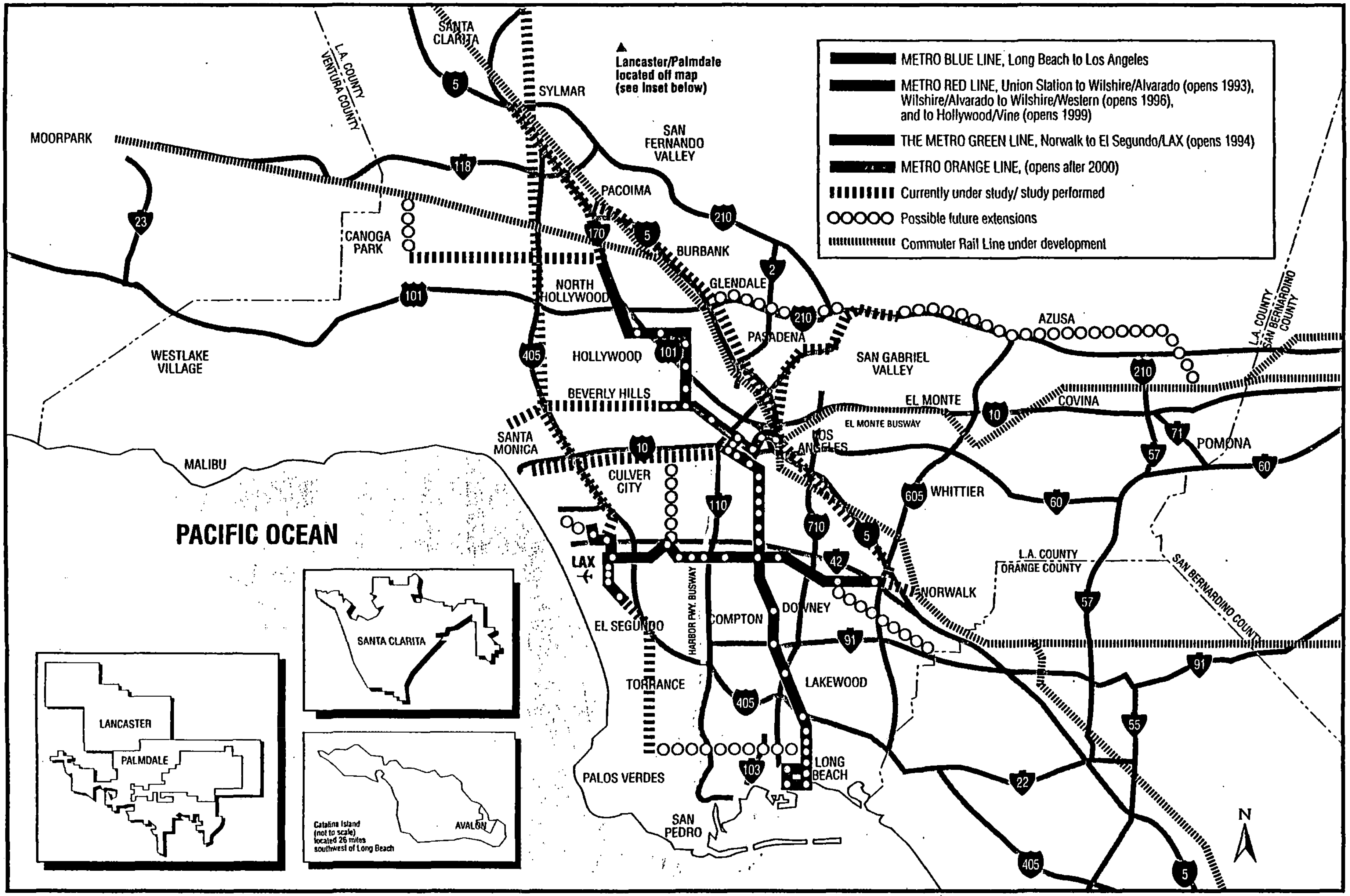


FIGURE 6-6

LOS ANGELES UNION PASSENGER TERMINAL

SCALE: 1"=125'

Los Angeles
300-Mile Metro Rail Plan



May, 1991

FIGURE 6-7

Implementation Issues

The entire Interstate 5/SPTC corridor north from downtown Los Angeles is suitable for higher speed operation. Numerous grade crossings on the corridor would have to be grade separated and certain curves would have to be smoothed out. One unknown factor at this point is the impact of the Red Line's opening in March 1993 and the recent opening of Metrolink upon LAUPT's operation. If ridership projections are met or exceeded, LAUPT could be an extremely busy place, with inherent capacity problems to follow. One question to be addressed in the near future will be LAUPT's capacity to absorb additional operations in the form of maglev/high speed rail.

6.3 San Diego

Description of Existing Transportation Terminals

The rail passenger terminal in San Diego is located at the northwest corner of Kettner Boulevard and Broadway, as shown in Figure 6-8. The terminal, formerly owned by the ATSF, was recently sold to Catellus Development Corporation; however, ownership of the railroad trackage remains with the ATSF. A 2-track main line bisects the station site, with a third through-track branching off in the station area. Three continuous low-level platforms, ranging in length from 265 meters (870 feet) to 341 meters (1120 feet), provide service to rail passengers. A total of 9 stub-ended tracks are located both east and west of the main tracks, with maximum degrees of curvature from 7° 30' to 14° 30'. The maximum degree of curvature on the main line is 8° 00'.

The rail terminal (Santa Fe Depot) is well located within downtown San Diego, providing easy access to numerous hotels, restaurants and retail stores. The terminal design is simple and straightforward, and can easily accommodate bi-level commuter rail equipment. The San Diego Trolley used to terminate on 'C' Street across from the depot, but now continues through the recently-completed America Plaza office tower, across the front of the depot property and through the Broadway intersection as part of the recently-opened Bayside line. The first two stations on the North Line were opened in July 1992, and provide a direct connection to Amtrak at the Santa Fe Depot and service to the San Diego County Administration Center. The only electrification in the area is the overhead catenary system which powers the San Diego Trolley.

Corridor Characteristics

As the railroad corridor proceeds north out of the Santa Fe Depot area, the trackage continues as the planned Metropolitan Transit Development Board's (MTDB) North Line Extension to the historic district called Old Town. Construction of this 5.4 km (3 mile) long, $30.9 million extension started in July and is expected to open in late 1995. This line will pass within 1.6 km (one mile) of the San Diego Zoo in Balboa Park, and within 1.6 km (one mile) of the San

Diego International Airport terminal. The railroad trackage adjacent to the airport uses curvature in the 1 to 3-degree range to parallel Interstate 5 (the San Diego Freeway) as it proceeds out of downtown, and has numerous grade crossings south of Interstate 8.

North of Interstate 8, the railroad corridor is grade separated for the most part and is parallel to and just east of the San Diego Freeway. It passes within 2.4 km (1.5 mi) of Sea World Aquatic Park located in the Mission Bay area. The railroad corridor departs from the San Diego Freeway alignment north of California Highway 52 and turns east to pass by the Miramar Naval Air Station. Further north, it turns back west, crosses under the San Diego Freeway and generally parallels the Pacific Ocean coastline toward Los Angeles.

Future Plans

MTDB has in place a year 2005 Rail Plan, which plans extensions to the LRT system in a number of directions. The planned North Line will eventually extend from Old Town to the Del Mar area, a distance of about 48 km (30 miles). Under study are future extensions which will serve the San Diego International Airport (Airport / Point Loma Segment), Mission Bay (Mission Bay Segment) and Miramar N.A.S. (Miramar Road Segment).

The MDTB and the North San Diego County Transit Development Board, in joint operation, recently concluded right-of-way negotiations for a 68.8 km (45 mile) commuter rail system from downtown San Diego to Oceanside. This system is scheduled to open in January 1993.

Implementation Issues

The railroad corridor entering San Diego from the north is generally favorable for higher speed operation. If maglev were to be implemented, it could probably follow the planned LRT / commuter rail alignment for the most part. Grade crossings would have to be eliminated and speeds would have to be adjusted to fit the existing curvature. Because of the highly developed nature of the adjacent land use, there are not many opportunities to "flatten out" the existing curvature. North of State Highway 52, it would be more favorable to follow the Interstate 5

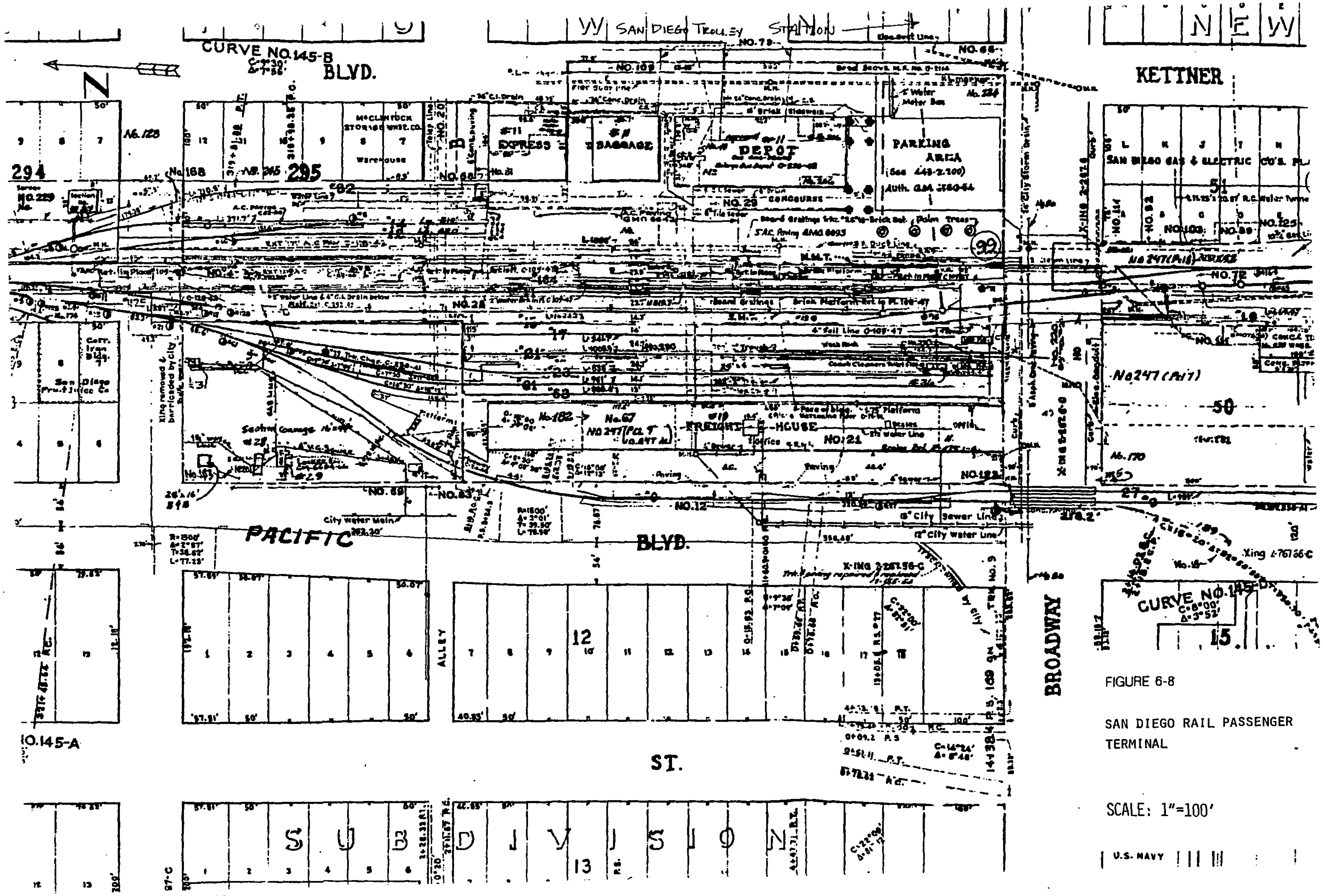


FIGURE 6-8

SAN DIEGO RAIL PASSENGER TERMINAL

SCALE: 1"=100'

U.S. NAVY

(and planned North Line LRT Extension) alignment rather than the railroad corridor. The Interstate 5 alignment is much more straight-forward in this area, and passes much closer to the University of California - San Diego campus.

6.4 St. Louis

Description of Existing Transportation Terminals

The old Union Station in St. Louis is located on Market Street between 18th and 20th Streets, and is a grand terminal in the old tradition. The terminal is on the National Register of Historic Places and went through an extensive renovation in the late 80's. The terminal is now home to a top-quality hotel and numerous restaurants and retail outlets. The former train station had a total of 32 stub-ended tracks and 17 low-level platforms in its heyday, with 2 yard throats and an extensive system of turnouts to accommodate movement onto and off of the 5-track main line running in an east-west direction. An extensive system of pedestrian and baggage tunnels served the terminal area, and a street trolley was located at Market and 20th Streets.

The main tracks are owned by the Terminal Railroad Association of St. Louis, a corporation jointly owned by the Union Pacific, Burlington Northern, Southern Pacific, CSX, Norfolk Southern and Illinois Central Railroads. All but 4 of the stub-ended tracks at Union Station have been removed and the wooden platforms have been replaced by low-level concrete platforms ranging in length from 262 meters (860 feet) to 305 meters (1,000 feet). Amtrak relocated from the terminal years ago and now operates from a small facility at 16th Street. A single wye track, with 13° 00' curvature, gains only eastbound access to the main tracks.

The terminal is located about 1.6 km (1 mile) west of the central business district. The new Metro Link LRT system now under construction will have a station in the terminal, located at the existing baggage tunnel under 18th Street near Clark Avenue (see Figure 6-9). The Metro Link LRT system is scheduled to open in July 1993 and will provide fast and convenient transportation to all points of interest in the downtown St. Louis area, as well as to the Lambert St. Louis Airport. In the airport, Metro Link will stop about 45 meters (150 feet) from the airline ticket counters inside the terminal. The Metro Link yard and shop complex is located in the southwest quadrant of Jefferson and Scott Avenues, about five blocks west of Union Station.

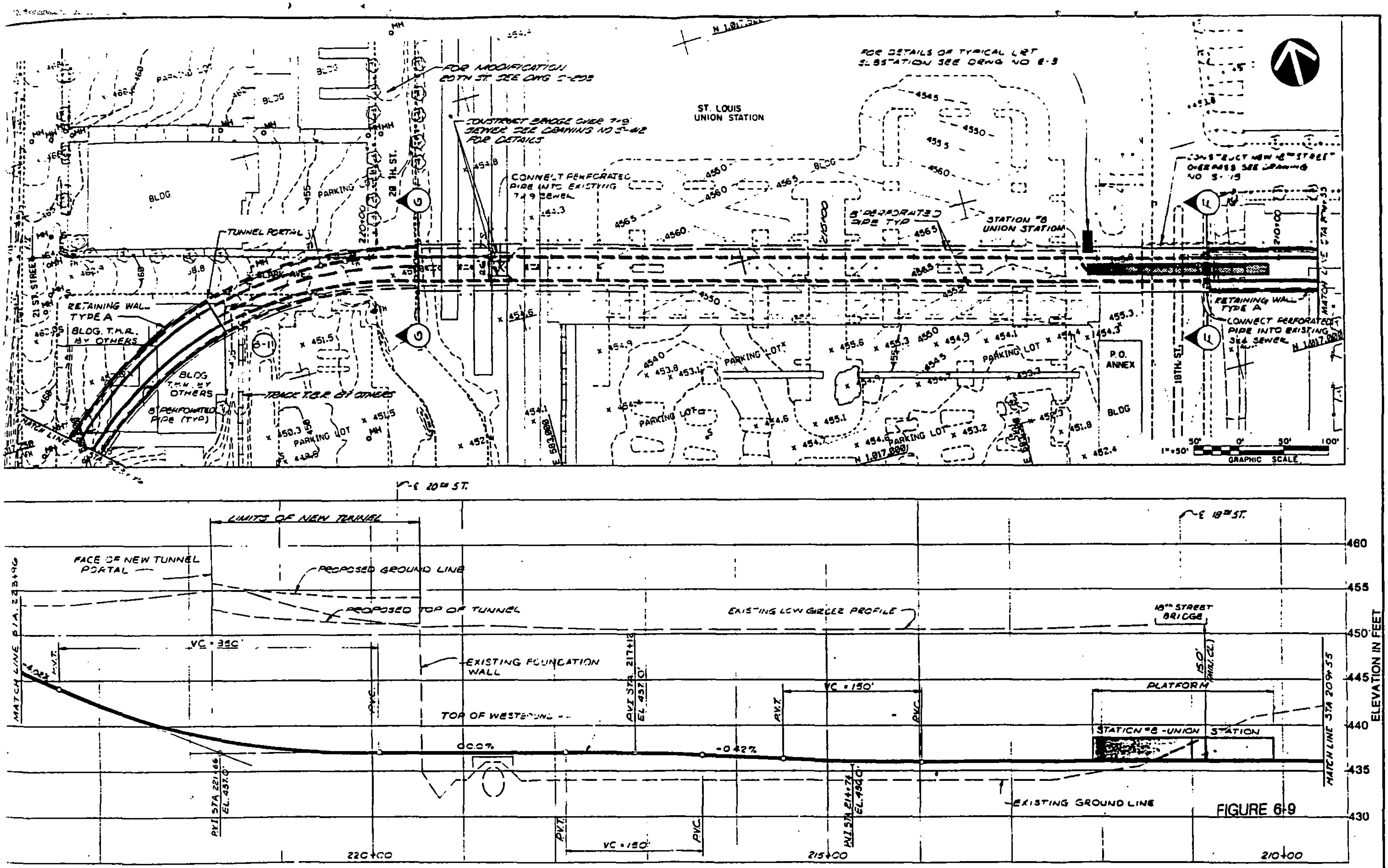


FIGURE 6-9

DESIGNED / DRAWN / CHECKED / APP. BY: / APP DATE	Campbell Design Group Fleming Corporation Hurst-Rosche Engineers, Inc. KAI Engineering, Inc. SUBMITTED: ____ DATE	Sverdrup & Parcel and Associates, Inc. 801 North Eleventh St. Louis, Missouri 63101 APPROVED: ____ PROJECT DIRECTOR DATE	EAST-WEST GATEWAY COORDINATING COUNCIL ST. LOUIS LIGHT RAIL PROJECT PRELIMINARY ENGINEERING APPROVED: ____ DIRECTOR OF ENGINEERING DATE	LRT - PLAN & PROFILE UNION STATION STA. 209+55 TO STA. 223+96	CONTRACT NO. DRAWING NO. C - 115 SCALE: 1"=50' SHEET NO. 30

APP. DESCRIPTION

Corridor Characteristics

As one approaches St. Louis from the northeast, numerous railroad corridors are available in the Granite City / East St. Louis area. Among the railroads operating in the area are the Burlington Northern, Southern Pacific, Conrail, Illinois Central, Union Pacific, Norfolk Southern, Alton & Southern, CSX, and the Terminal Railroad Association of St. Louis (TRRA). Many of these corridors approaching St. Louis have long segments of tangent trackage connected with relatively large-radius curvature, and three of these major corridors converge near the town of Mitchell. There is an extensive and complex system of railroad storage yards, interlockings, grade separations and grade crossings in the area immediately across the Mississippi River from St. Louis.

Currently, railroad trains crossing the river do so over two bridges - Merchants Bridge and MacArthur Bridge. Both bridges are owned and operated by the TRRA. At one time, railroad traffic also used the historic Eads Bridge just north of downtown St. Louis. However, during the planning of the Metro Link LRT system, a unique ownership swap was arranged. TRRA donated the Eads Bridge to the Bi-State Development Agency, the organization charged with building Metro Link. The Eads Bridge is a 2-level structure built in 1874 and is currently being rehabbed for operation of the LRT system on its lower level. In turn, Bi-State donated the MacArthur Bridge to the TRRA. Railroad traffic westbound on the MacArthur Bridge access the railroad corridor which runs in an east-west direction just south of downtown St. Louis, on which is the Union Station terminal. Railroad traffic westbound on the Merchants Bridge access a railroad corridor which now runs south toward downtown St. Louis along the Mississippi Riverfront. This corridor is somewhat more circuitous and enters a tunnel beneath the Gateway Arch before entering the same railroad corridor south of downtown. Both corridors into downtown St. Louis include a mix of both grade separations and grade crossings.

Future Plans

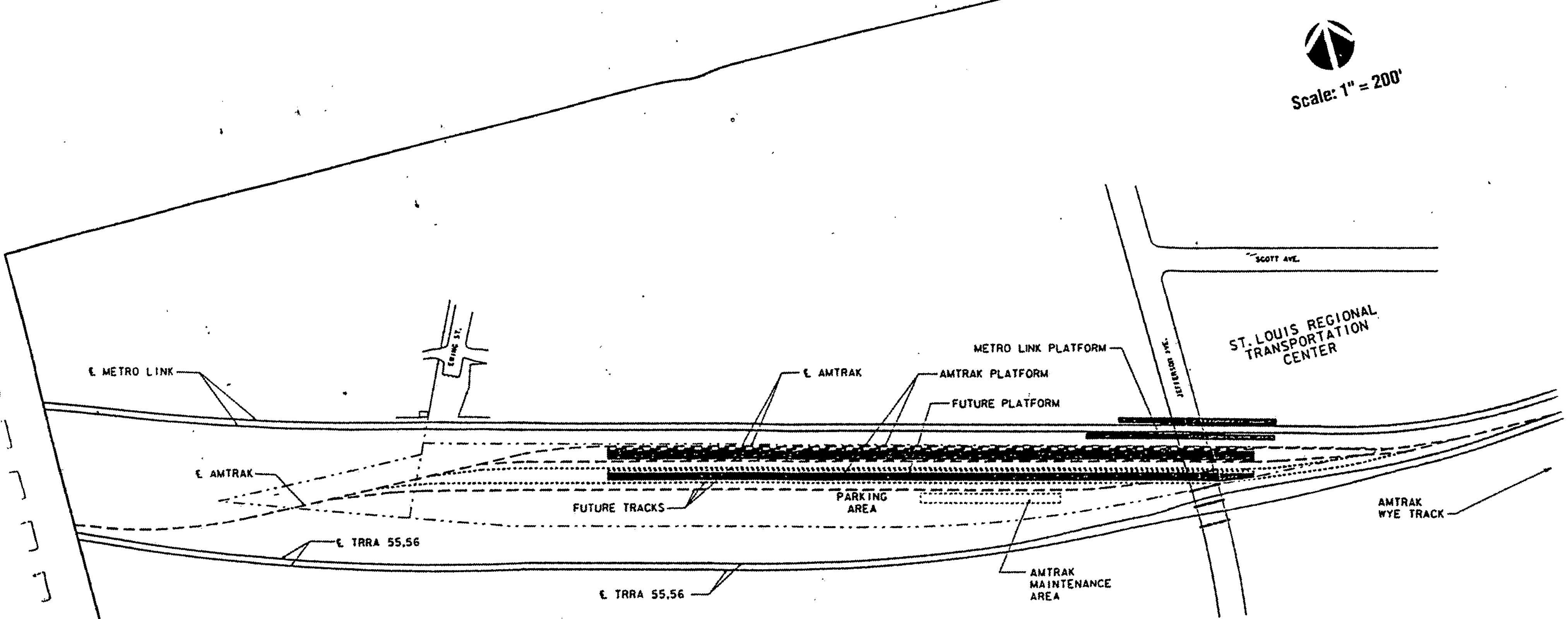
The city of St. Louis has been studying the possibility of constructing a new multimodal transportation facility just west of Union Station. The proposed site is in a former railroad yard now owned by the City of St. Louis at the southeast quadrant of Jefferson and Scott Avenues (see Figure 6-10), across Jefferson Avenue from Metro Link's yard and shop complex. The proposed $36-million facility would link Amtrak, Greyhound, Metro Link and helicopter operations in a comprehensive transportation center, with space for future rail (e.g., high speed) activities. Also included at the center would be multi-story parking, taxi, bus maintenance, rail servicing, ticketing, baggage handling, concessions and restroom facilities. The transportation center could also act as an express bus transfer point, because of its easy access to the street and freeway systems. Small package handling could also be a possible use since United Parcel Service operates a distribution center across Scott Avenue from the proposed facility.

The proposed project could be attractive to both Greyhound and Amtrak as a result of other projects. Greyhound will be displaced by the domed stadium project adjacent to Cervantes Convention Center. Amtrak's operation at its present location could be impacted by two proposed projects:

- an 18,000-seat Kiel Center arena with a 2,100-car parking garage; and
- a proposed equestrian center for some 1,800 horses along with 4,500 parking spaces south of Clark Street.

Implementation Issues

Any proposed high speed technology would almost certainly be on new aerial structure as it approached the vast railroad/industrial complex in the Granite City/ East St. Louis areas. Whether or not the new system could use one of two remaining railroad crossings over the Mississippi River will need to be addressed at a later time. If an existing crossing is used, the MacArthur Bridge would be preferred because of its superior alignment characteristics as it enters the downtown St. Louis area.



Source:
St. Louis Regional Transportation Center Feasibility Report, February 1991

FIGURE 6-10

Sverdrup

Regarding possible terminal location, it appears the city is furthering its plan to construct a new multimodal transportation center. However, a re-examination of the Union Station site should be made. The terminal has a tremendous unused capacity for railroad/high speed rail / maglev operations - capacity which can be utilized for a fraction of the cost of providing new facilities elsewhere. It has undergone a dramatic and award-winning renovation and is considered a focal point for activities on this side of downtown. At the same time, use of Union Station as the new transportation center would negate the need to construct another Metro Link station at Jefferson Avenue. This could save as much as $4.8 million, since Union Station will already be well served by Metro Link.

6.5 Chicago

Description of Existing Transportation Terminals

The city of Chicago has a total of five (5) past or present commuter rail stations which deserve some consideration as possible terminals for maglev technologies. Chicago Union Station is located at the corner of Adams and Canal in the southwest corner of Chicago's Loop. The station is owned by the Chicago Union Station Company and serves as the downtown station for the Amtrak system. A $32-million Passenger Facility Improvement project was completed last year, and the interlocking plant is undergoing a $55-million rehabilitation. Various railroads own trackage which emanates from CUS, including the Soo Line (former Milwaukee Road), Norfolk Southern, Conrail, METRA (the commuter rail operator in Chicago) and the Burlington Northern (BN). The Chicago & Northwestern Transportation Company also operates commuter trains immediately north of the CUS Terminal at the Northwestern Station, which is presently undergoing a $73-million rennovation of its trainshed, platforms and associated facilities. The LaSalle Street Station, located at LaSalle and VanBuren Streets, is home to the METRA-Rock Island commuter rail service, and is undergoing a $57.5 million rehabilitation. However, only Chicago Union Station (CUS) has a bi-directional capability and flow-through configuration which allows more operational flexibility, and consequently, a greater opportunity for geographic coverage over existing railroad facilities. This study will investigate the possibilities at CUS.

The track configuration at CUS consists of 10 stub-ended tracks approaching from the north and 13 stub-ended tracks from the south sharing a common concourse area, as shown on Figure 6-11. A series of 12 low-level platforms provides access to these tracks, and a single through-track branches into two tracks for operational flexibility. The platforms average about 305 meters (1000 feet) in length, are staggered to match the turnout ladders, and are continuous. The station is able to accommodate bi-level commuter rail equipment; however, present equipment pushes the maximum height allowed at CUS, and is equipped with "up-stops" to prevent vehicle contact with the station roof. A complex arrangement of double-slip and single-slip turnouts provide operational flexibility

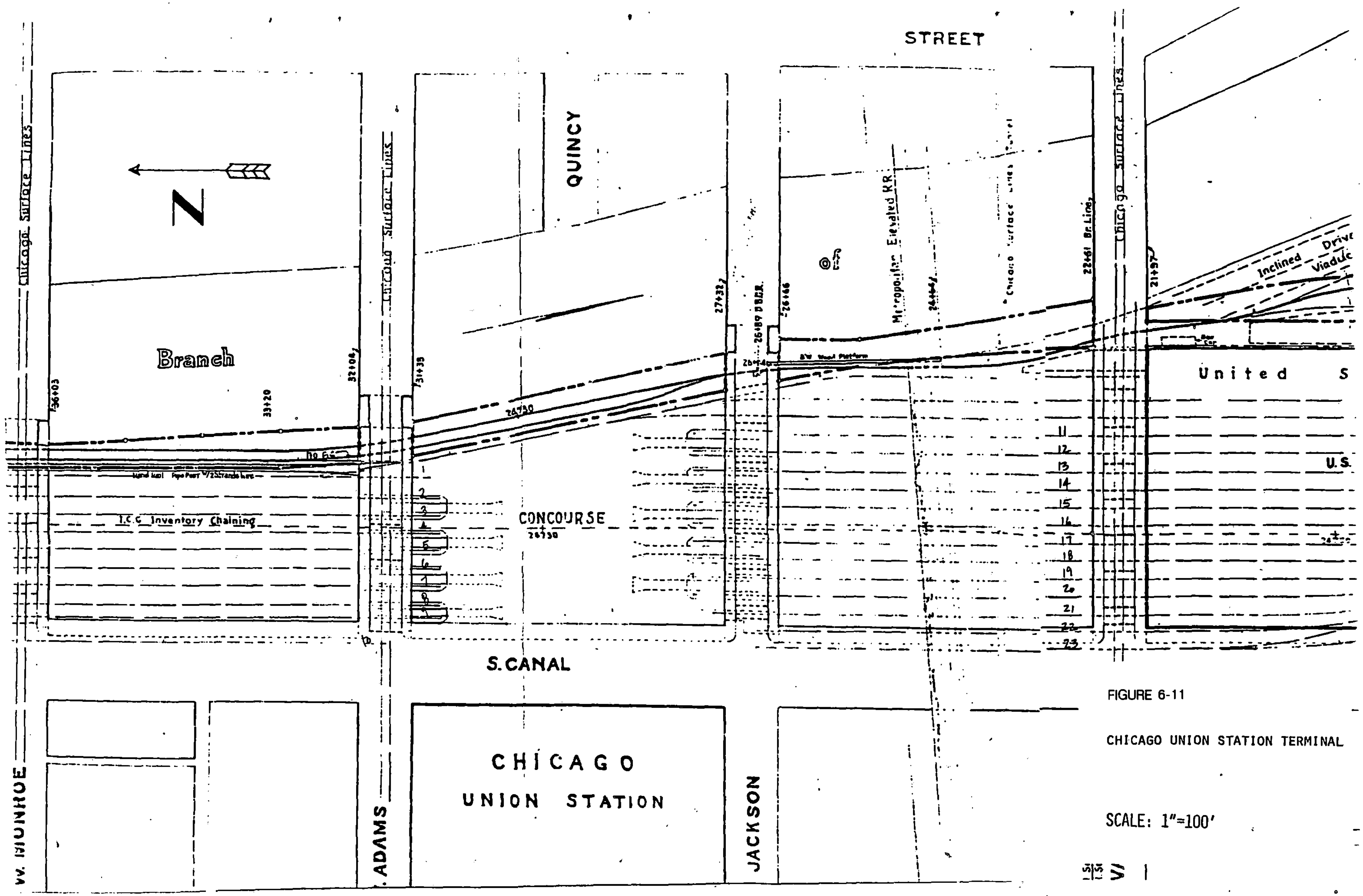


FIGURE 6-11

CHICAGO UNION STATION TERMINAL

SCALE: 1"=100'

at both the north and south ends of CUS, the busiest terminal in the Chicago metropolitan area The nearest Chicago Transit Authority (CTA) heavy rail transit station is located on the elevated structure at Quincy and Wells Streets, providing access to the comprehensive intracity transit network. The Metra Heritage Corridor, Conrail and Norfolk Southern (NS) trackage is accessed via a lift bridge over the South Branch of the Chicago River; however, there do not appear to be any horizontal or vertical clearance restrictions on the bridge.

Corridor Characteristics

There are numerous railroad corridors which access Chicago from the southwest, many of which have commuter rail systems or Amtrak operating on them. Amtrak currently operates from St. Louis over Southern Pacific (SPTC) trackage (formerly the Illinois Central Gulf Railroad) into CUS. The Atchison, Topeka and Santa Fe Railroad (ATSF) operates adjacent to the Southern Pacific / Amtrak alignment, which generally parallels the DesPlaines River / Chicago Sanitary and Ship Canal system. For the most part, these corridors are grade separated, due to their proximity to the river / ship channel.

The NS also operates both freight and commuter trains in the southwest metropolitan region, and METRA operates commuter trains over the old Chicago, Rock Island & Pacific Railway tracks. The SPTC / Amtrak and NS corridors access Chicago Union Station whereas the METRA / Rock Island Corridor access LaSalle Street Station. ATSF has no commuter rail operation today.

Future Plans

The single most important transportation improvement for the Chicago metropolitan area is the planned Chicago Central Area Circulator project. This $750-million light rail transit system would better connect the Chicago Union Station and Northwestern Station commuter terminals to the Chicago Loop and Near North business, entertainment, educational and retail areas. The "Circulator" would also improve the connection to the CTA's West and Northwest Lines. The CTA's Northwest Line ends in the terminal of O'Hare International Airport.

Lines. The CTA's Northwest Line ends in the terminal of O'Hare International Airport.

Implementation Issues

Of all the existing corridors in the southwest Chicago metropolitan area, the one most suited to high speed application is the SPTC / Amtrak / ATSF Corridor. This corridor generally has long tangent sections connected by gentle curves. The adjacent land use in the outlying areas is mainly industrial with low density commercial and residential interspersed. The density of development increases as one gets closer to Chicago; however, the right-of-way is still well suited for high speed operation. Midway Airport is located about 3.2 km (2 miles) south of this alignment. The NS and Rock Island corridors are much more residential in character and contain more physically constraining features as one approaches Chicago.

The most challenging portion of alignment on the SPTC / Amtrak alignment is at its confluence with the Conrail and Norfolk Southern trackage just south of the South Branch of the Chicago River. Here, the alignment turns north along a 9°30' curve (approximate) and crosses the river over the previously discussed lift bridge. A better alignment alternative through this area should be investigated at some future date.

In concept, Chicago Union Station appears to be a good possibility for a future maglev terminal. There are no major physical restrictions, an extensive renovation of the station is being completed and the planned Central Area Circulator project would use CUS as the southern terminus. However, CUS is a very busy commuter terminal and an analysis of present and future operations would be necessary if the station is considered further as a possible maglev terminal.

6.6 Cleveland

Description of Existing Transportation Terminals

Cleveland presently operates rail service at two locations - Lakefront Station and Tower City Terminal. Lakefront Station is located on Cleveland Memorial Shoreway, directly across the freeway from Cleveland Stadium, and is owned and operated by Amtrak (see Figure 6-12). The main tracks are owned by Conrail (formerly the old New York Central) and are very nearly tangent in the station area. An elevated pedestrian walkway just west of the station serves a single 198 meter (650-feet) long low-level platform. Lakefront Station is located about 1.6 km (1 mile) southwest of Tower City Terminal, and is located outside the CBD area.

Tower City Terminal (TCT) has recently undergone a dramatic transformation - from the antiquated Cleveland Union Terminal (CUT) to a modern mixed-use highrise development with integrated transportation facilities. Two levels of retail shops are intermingled with a food court and an office complex overhead. The Greater Cleveland Regional Transit Authority (GCRTA) now operates both heavy rail transit (HRT) and LRT in the station, both modes transferring across a large center platform under Prospect Avenue. Both the HRT and LRT are powered with overhead catenary at 600 volts DC. GCRTA also operates its HRT system to Cleveland - Hopkins International Airport.

Corridor Characteristics

The present intercity train service operates over Conrail's Lakeshore Route, an alignment which has long sections of tangent trackage connected with curves in the one to two-degree range. This alignment passes the Burke Lakefront Airport, Municipal Stadium and the developing Flats entertainment district, and then turns south away from Lake Erie to pass alongside the Cleveland - Hopkins International Airport. As the railroad alignment departs Lake Erie, the GCRTA heavy rail system to Hopkins Airport shares this right-of-way.

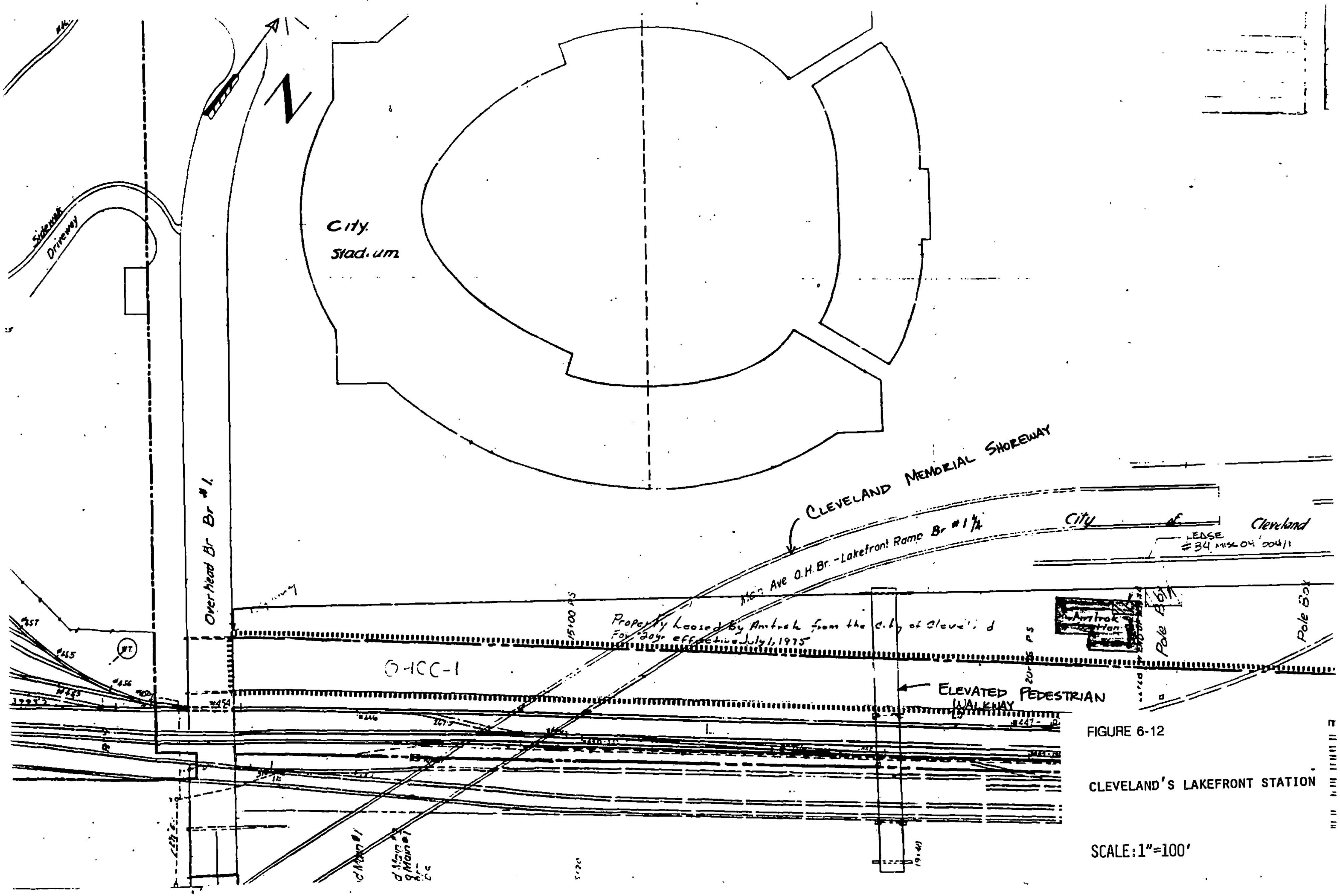


FIGURE 6-12

CLEVELAND'S LAKEFRONT STATION

SCALE:1"=100'

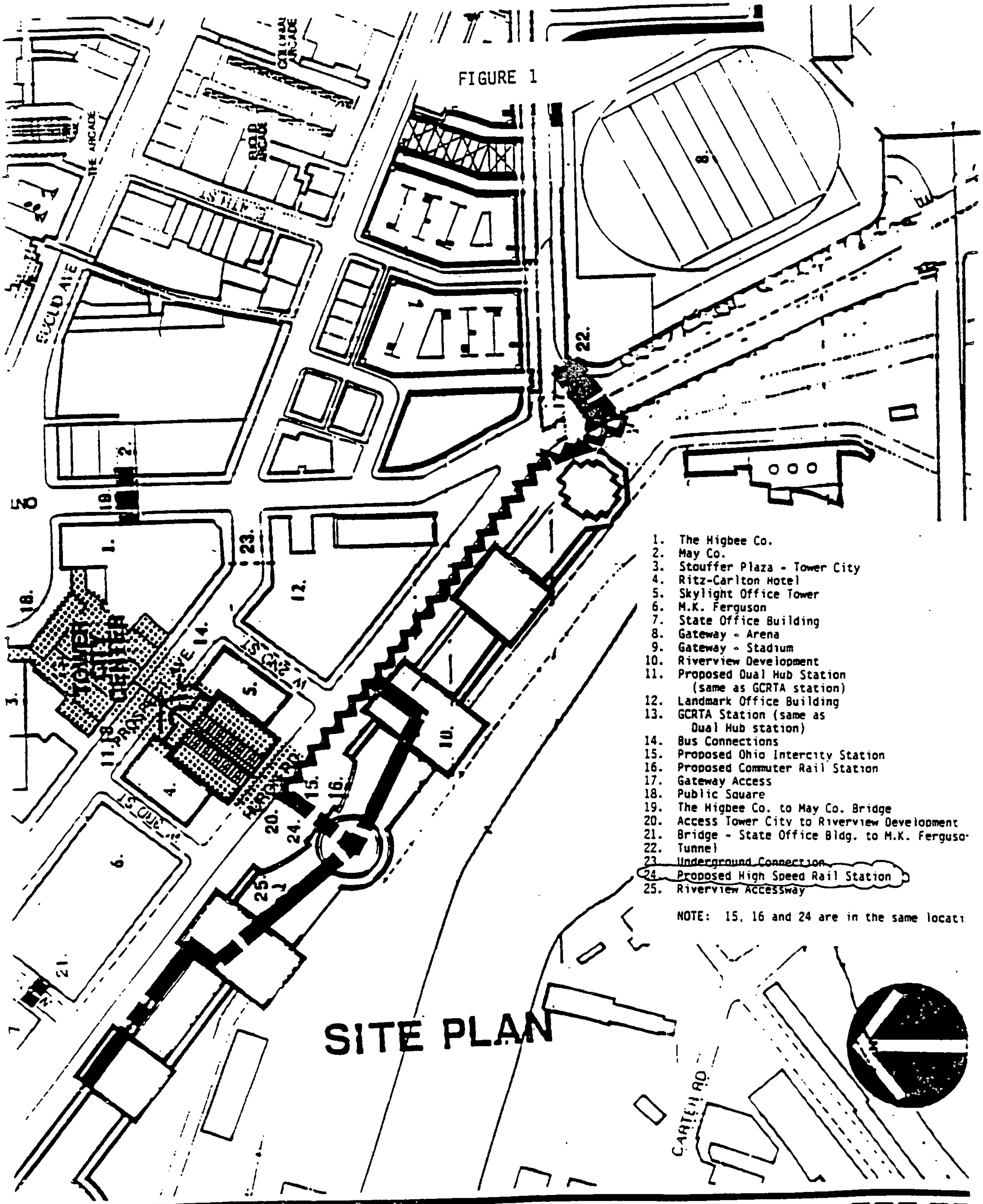
Future Plans

There has been discussion about a possible intermodal terminal in downtown Cleveland located next to the Tower City Terminal complex. The studies concluded that restoration of passenger rail service was both desirable and feasible, and could be linked to a number of other activity centers (see Figure 6-13). Since the TCT does not now have commuter or intercity rail operations, the possibility of gaining that service in proximity to existing HRT and LRT systems is most exciting from an integrated transportation framework. The proposed intermodal terminal is also across the street from the $350-million Gateway Sports Complex. This complex, now under construction, will be home to a new basketball arena and a baseball stadium and should be completed by 1994. A climate-controlled connection between the two activity centers was constructed recently. The next planned phase of the Tower City complex would add both intercity (i.e., Amtrak) and commuter rail facilities, along with a Riverview development (see Figures 6-14 and 6-15). A future Flats trolley line would use abandoned railroad trackage to connect the developing Flats entertainment districts to the terminal.

Amtrak used the old CUT back in 1971, but moved to the Lakefront Station to terminate an annual lease for about 4.8 km (3 miles) of trackage. The move from Lakefront Station to Tower City Terminal would be beneficial for a number of reasons but would cost about $42 million for reconstruction and rehabilitation of approximately 43 km (27 miles) of existing railroad trackage. The planned railroad trackage to be used to access the Tower City Terminal would depart Conrail's Lakeshore line near Collinwood Yard and would meet it again south of Hopkins Airport near Berea, as shown on Figure 6-16. A new passenger station at Tower City would cost an additional $11 million, bringing the total cost to $53 million.

Implementation Issues

If the above-discussed plans are implemented, the Tower City Terminal would become the focus of transportation in northeast Ohio. Completion of the proposed Dual Hub-transit project (which would connect downtown and



Source: Privatization Study For Intermodal Transportation, July 1992

FIGURE 6-13
Cleveland's Proposed Tower City Terminal/Gateway Sports Complex

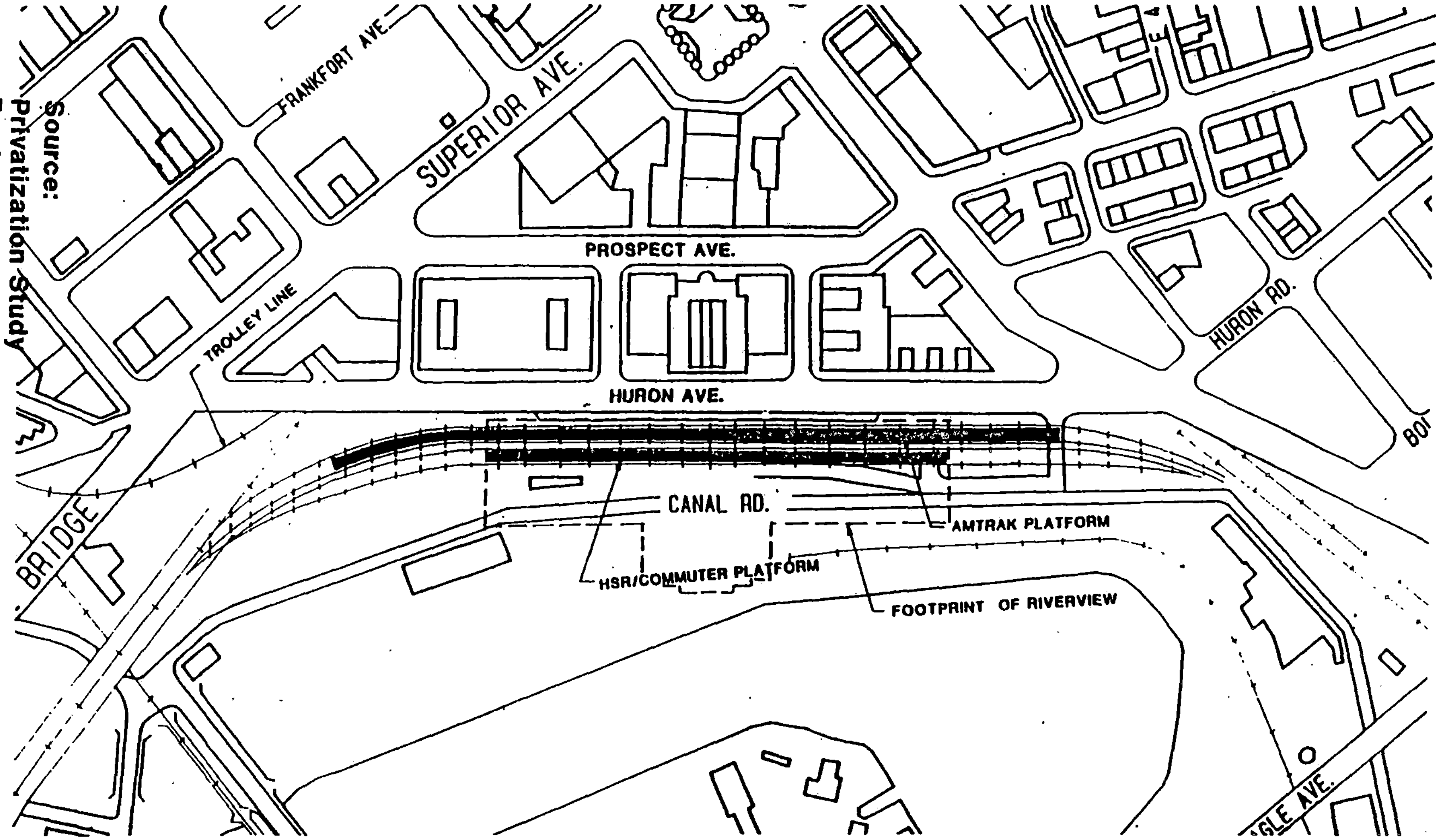
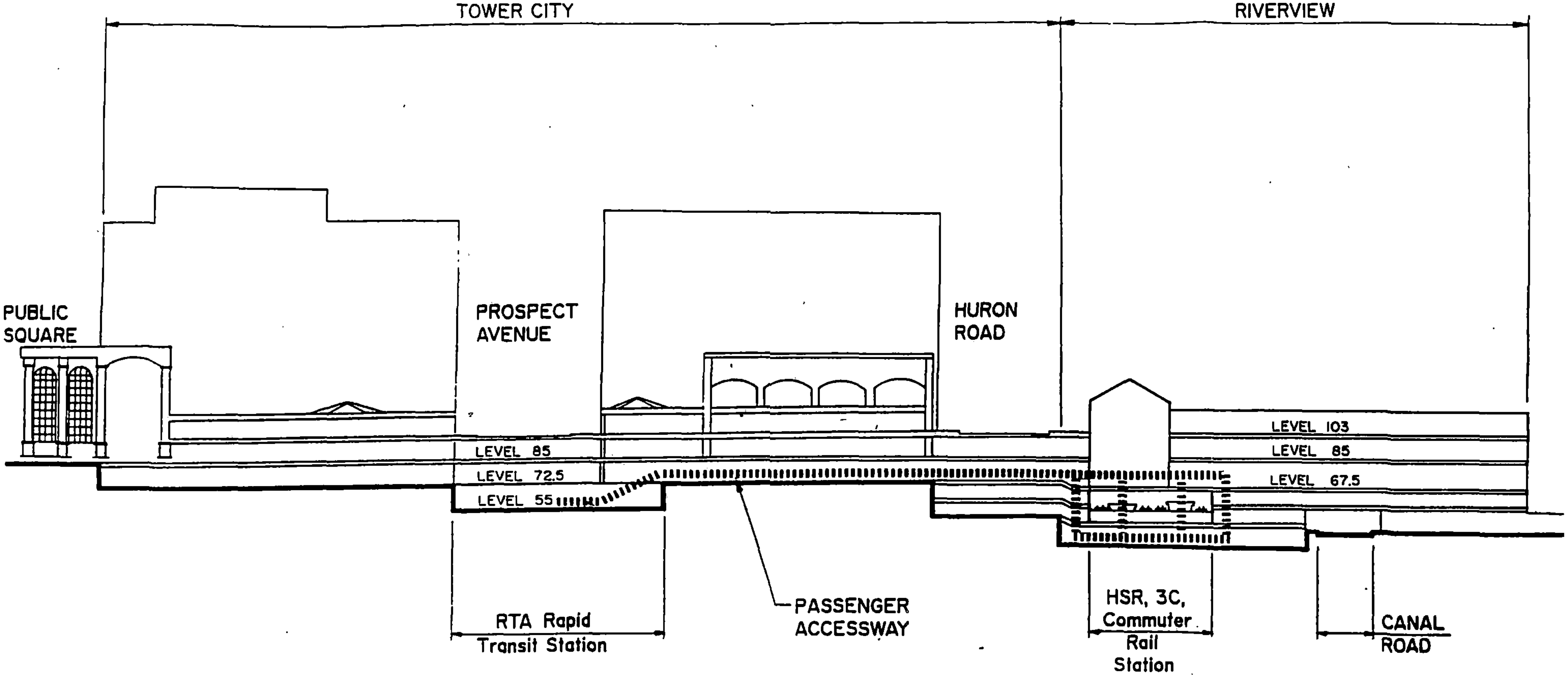


FIGURE 3

Source:
Privatization Study
For Intermodal
Transportation,
July 1992

RAIL HORIZONTAL ALIGNMENT
AT TOWER CITY HUB

FIGURE 6-14

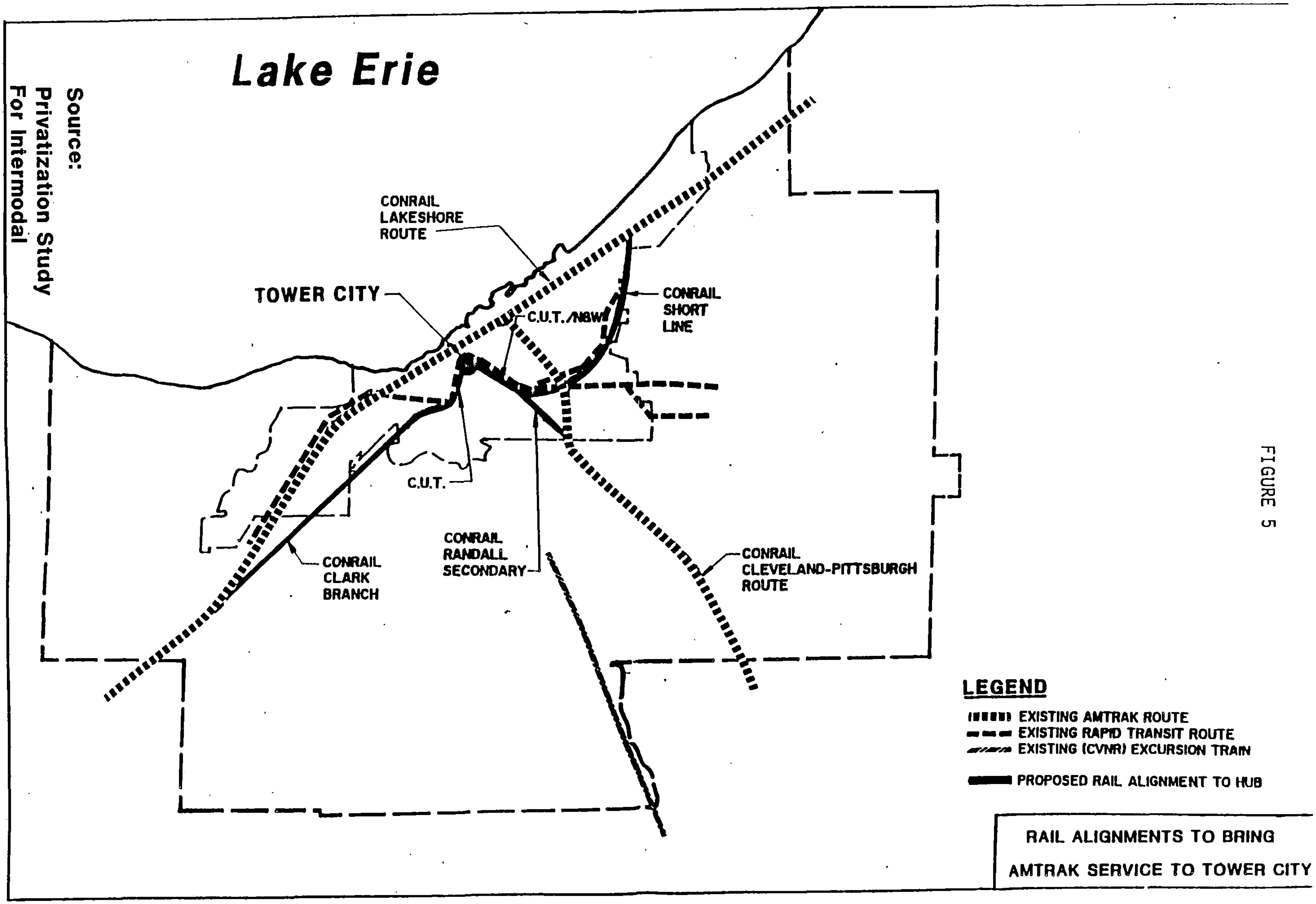


Source:
Privatization Study For Intermodal Transportation, July 1992

FIGURE 6-15

PASSENGER ACCESSWAYS WITHIN INTERMODAL HUB

Source:
Privatization Study
For Intermodal
Transportation,
July 1992



RAIL ALIGNMENTS TO BRING
AMTRAK SERVICE TO TOWER CITY

FIGURE 5

FIGURE 6-16

University Circle with the HRT system in a more direct route) would further increase its benefits. The rehabilitated railroad alignments necessary to access the TCT are certainly more circuitous than those encountered on the Lakeshore alignment, and would be less suitable for high speed operation. However, the TCT is well situated as an intermodal transportation hub, and the benefits of accessing this terminal with high speed transportation technologies far outweigh the costs of lower speed operation over some segments of the new alignment. Improvements to these existing corridors to allow higher speed operation should be evaluated.

6.7 Buffalo

Description of Existing Transportation Terminals

The downtown intercity rail terminal in Buffalo is the Exchange Street Station, located on Exchange Street just one block east of the Memorial Auditorium (see Figure 6-17). The two-track corridor is in an open cut structure through the downtown area, but only contains one track today. Amtrak owns and operates the station and Conrail (formerly New York Central) owns the trackage. The station is rather small and in good shape and is located underneath the elevated Interstate 190 Thruway. Pilot Field, the relatively new baseball stadium, is a short two-block walk from the station on Seneca Street. The Niagara Frontier Transportation Authority's (NFTA) Metro Rail LRT System operates on Main Street from the Memorial Auditorium to the State University of New York's Amherst Campus, about 10.2 km (6.4 miles) to the north. The nearest Metro Rail Station is roughly two (2) blocks in either direction from Exchange Street. Only the Amtrak-Maple Leaf train operates through Exchange Street Station to Niagara Falls and Toronto.

The Central Terminal used to be the main railroad terminal in Buffalo, and is located about 3.2 km (2 miles) east of downtown on Memorial Drive between Elliott and Washington Streets. The passenger station contained at one time 14 double-ended tracks (4 have been removed). An overhead passenger walkway served the 7 low-level continuous platforms, which range in assumed length from 152 meters (500 feet) to 274 meters (900 feet). The station can accommodate bi-level commuter rail equipment and has a standard track design. William Street, a major east-west street, is located just south of the terminal complex. Today, the Central Terminal is abandoned and is in an advanced state of disrepair. Should the terminal be necessary for any future transportation activity, extensive rehabilitation would be required.

Amtrak has shifted much of its operation to Depew Station, located about 9.6 km (6 miles) east of downtown Buffalo. Two Amtrak trains going to destinations east and west of Buffalo take a different alignment which is less circuitous and bypasses downtown Buffalo. From the Depew Station, the Greater Buffalo

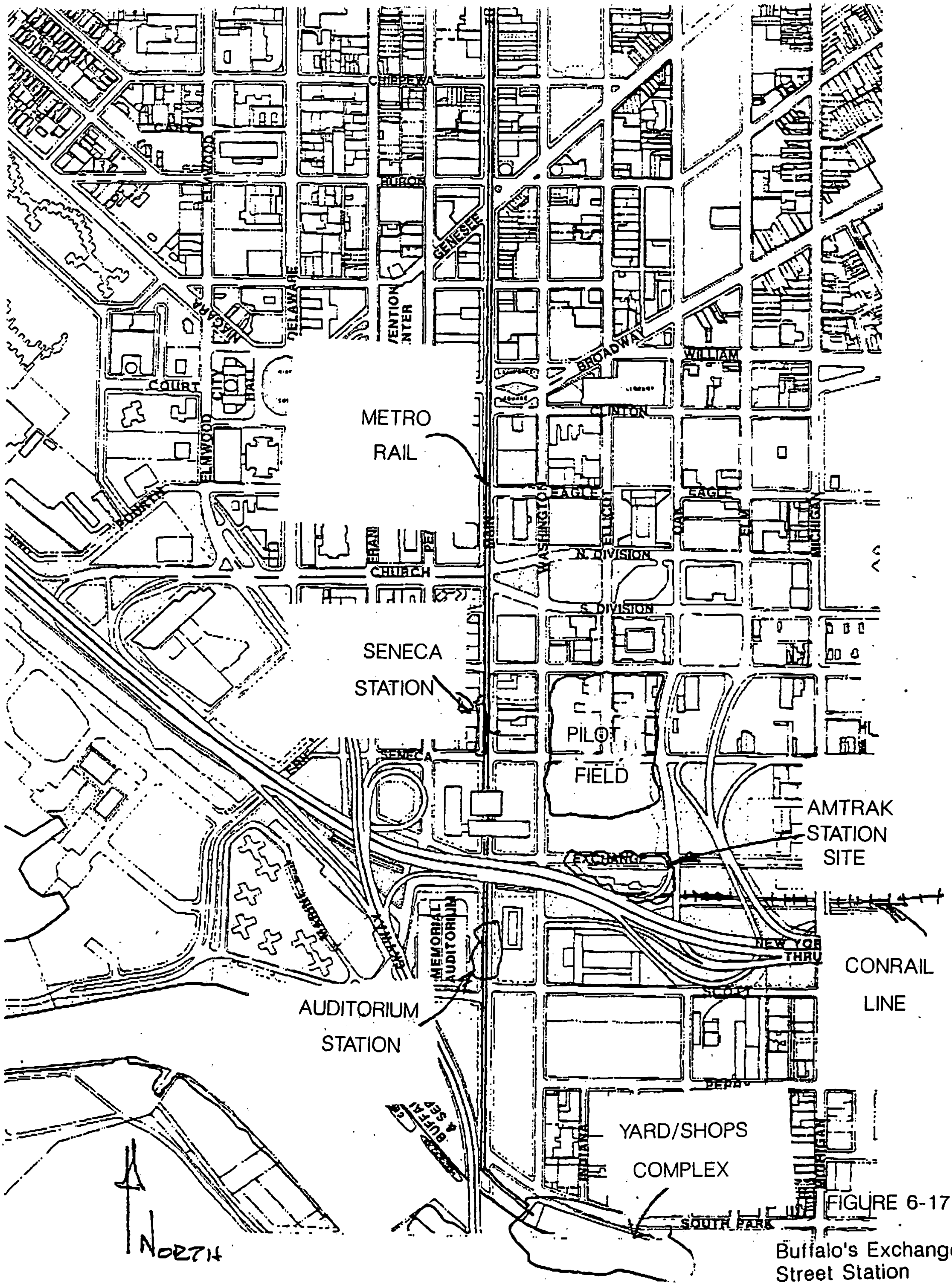


FIGURE 6-17
Buffalo's Exchange
Street Station

International Airport is about 3.2 km (2 miles) north of the railroad corridor. It appears that the alignment is straight and grade-separated through much of the downtown area, lending itself favorably to the high-speed maglev technology.

Corridor Characteristics

The New York State Department of Transportation has invested over $125 million in track improvements between Niagara Falls / Buffalo and New York City. Consequently, this trackage is in very good condition, is grade separated for the most part, and has long segments of tangent alignment. The alignment becomes more constricted about 3.2 km (2 miles) from Lake Erie and is complicated by tighter curves and railroad interlockings and storage yards adjacent to the Buffalo harbor area. As the alignment passes through the town of Blasdell, it turns southwest along the southern shore of Lake Erie and is quite straight. However, some grade crossings are encountered in this area.

Future Plans

At some point in the future, NFTA intends to construct a Metro Rail LRT extension to the Greater Buffalo International Airport.

Implementation Issues

The alignment, in general, is well suited for higher speed operation. The Exchange Street station is well located to serve as a possible intermodal terminal, close to downtown attractions and within close proximity to other transportation modes (i.e., intercity and intracity buses, Metro Rail). However, high speed transportation continuing on to points east and west of Buffalo would be required to make a reverse move (or change ends of the train) to access the main corridor through town, about 1.6 km (1 miles) to the east. This reverse move would not be required if the Central Terminal were used; however, the Central Terminal is not well located to serve downtown Buffalo and would require extensive renovation. One possibility for improving this Exchange St. station operation would be to construct west of the station a southbound connection to the existing lakefront trackage which parallels State Highway 5.

6.8 Rochester

Description of Existing Transportation Facilities

Rochester's intercity rail terminal is located on the northeast corner of Central and Clinton Avenues, just outside the inner loop as shown in Figure 6-18. Both Central and Clinton Avenues had trolleys operating on them at one time, and Clinton is a major north-south arterial. Amtrak owns and operates the terminal while Conrail owns the main line. A total of eight double-ended tracks served 4 low-level platforms, which ranged from 165 meters (540 feet) to 363 meters (1190 feet) in length. A passenger subway beneath the tracks was used to access the platforms.

The large intercity terminal (see Figure 6-19) was torn down some years ago and was replaced by a standard 1-story Amtrak facility, which remains on the site today. In the same time frame, five of the tracks were removed and 3 of the platforms were taken out of service, leaving only the northernmost track and 2 main tracks serving the remaining platform closest to the Amtrak terminal. The old rail terminal was connected at one time to the central U.S. Post Office Building, located on the southeast corner of Joseph and Central Avenues, by an underground tunnel. Today, much of the land between the two facilities is occupied by surface parking. This area of the city just north of the Inner Loop is considered to be in transition. The existing bus terminal is located about seven blocks south in the Midtown Plaza, directly across the street from Xerox Square. The No. 2 bus route serves the Rochester-Monroe County Airport, located about 6.4 km (4 miles) southwest of downtown.

Corridor Characteristics

The existing railroad corridor is elevated through the downtown area on either structure or retained fill and appears to be fairly well suited for higher speed operations. The maximum curvature found on the 4-track main line is a 10^{o} 00' curve about 0.8 km (1/2 mile) west of the station, and 2^{o} 00' curves are located both immediately east and west of the passenger station. East of the downtown area near Fairport, the Conrail main line is fairly tangent and generally parallels

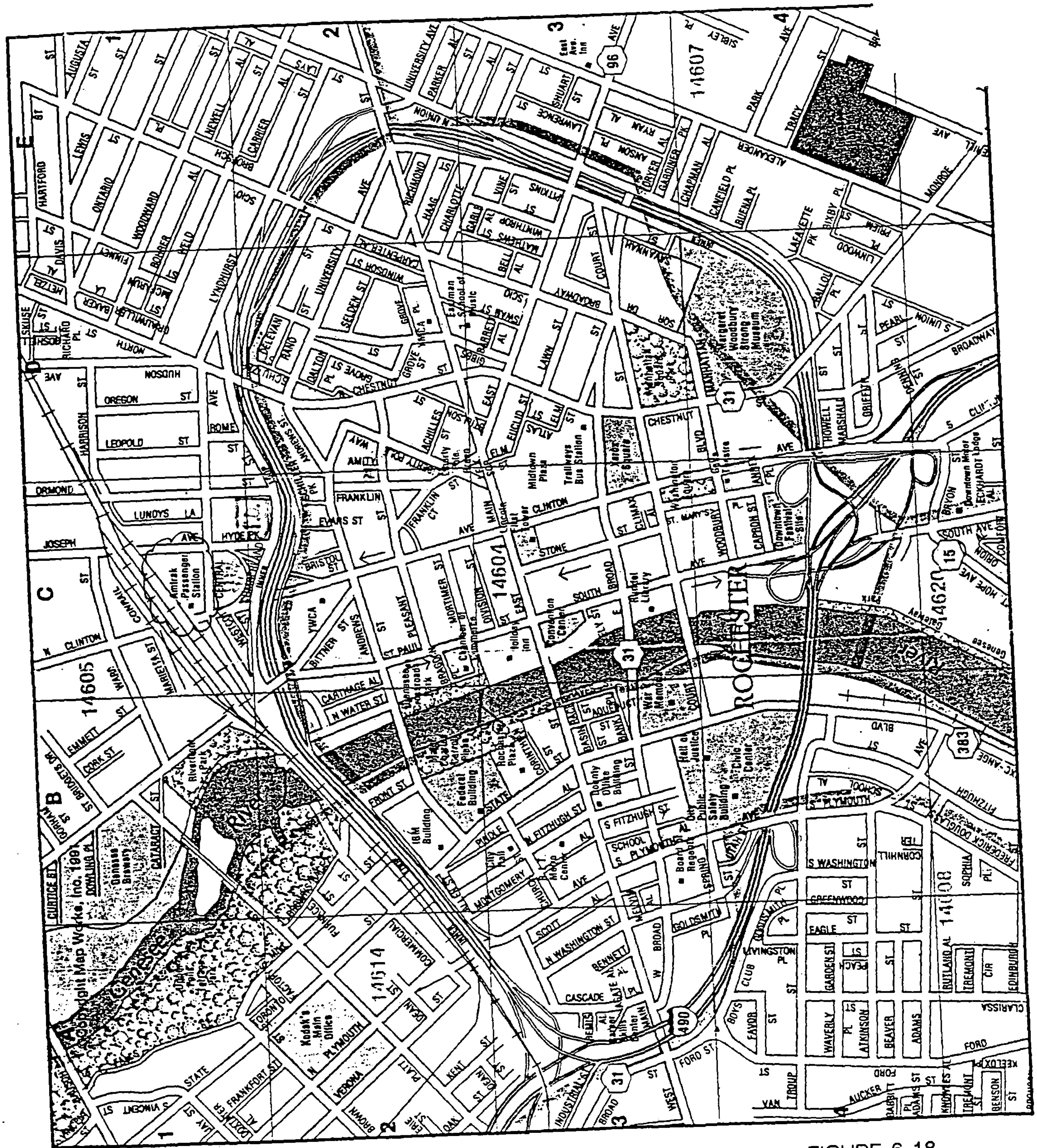


FIGURE 6-18

Downtown Rochester

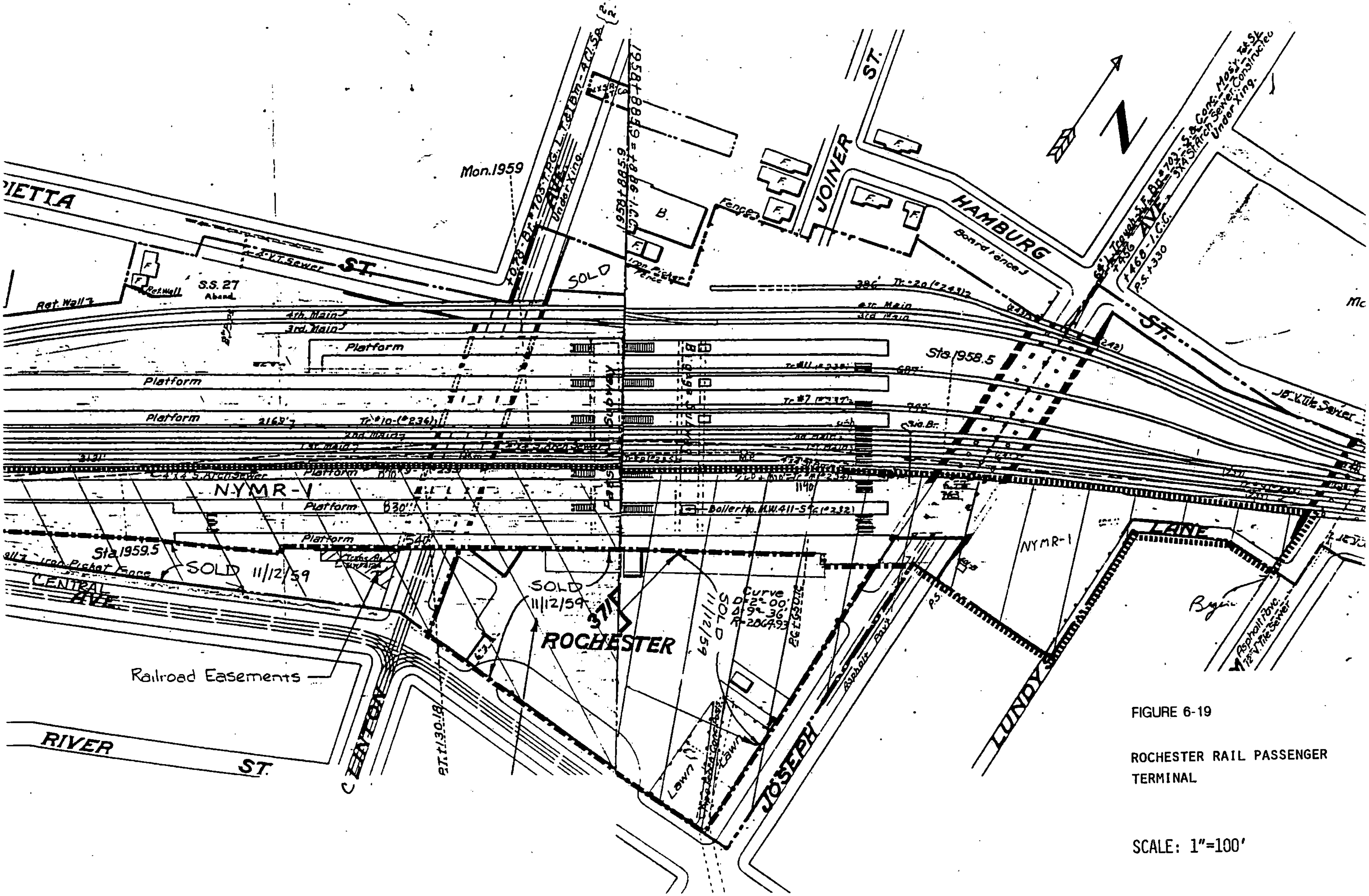


FIGURE 6-19

ROCHESTER RAIL PASSENGER TERMINAL

SCALE: 1"=100'

the Erie Canal. The curvature which connects the tangent trackage is in the one to two-degree range. East of downtown, the alignment is located just north of and adjacent to the University Avenue corridor. Just west of its crossing of the Genesee River, the most restrictive curvature (10°00') is found. The Kodak Company's main office is just north of the alignment at this point. The remainder of the corridor to the west has long tangent sections with gentle curvature, and passes about 2.4 km (1.5 miles) north of the airport.

Future Plans

There has been some discussion among civic leaders about a possible intermodal terminal facility to serve the Rochester metropolitan area, and numerous sites are being evaluated. There is some pressure to locate the facility in the suburbs; however, transportation council officials feel that the existing site combined with the U.S. Post Office would probably be most cost-effective. The Post Office is a large 1930's style structure which is presently 1/3 occupied, and could serve as an intermodal facility after extensive modifications.

Implementation Issues

For the most part, the railroad corridor appears to be well suited for high speed operation. Some curve smoothing and construction of grade separations would be required. Additional investigation into the best intermodal terminal site is needed, and will require input from a number of organizations.

6.9 Syracuse

Description of Existing Transportation Terminals

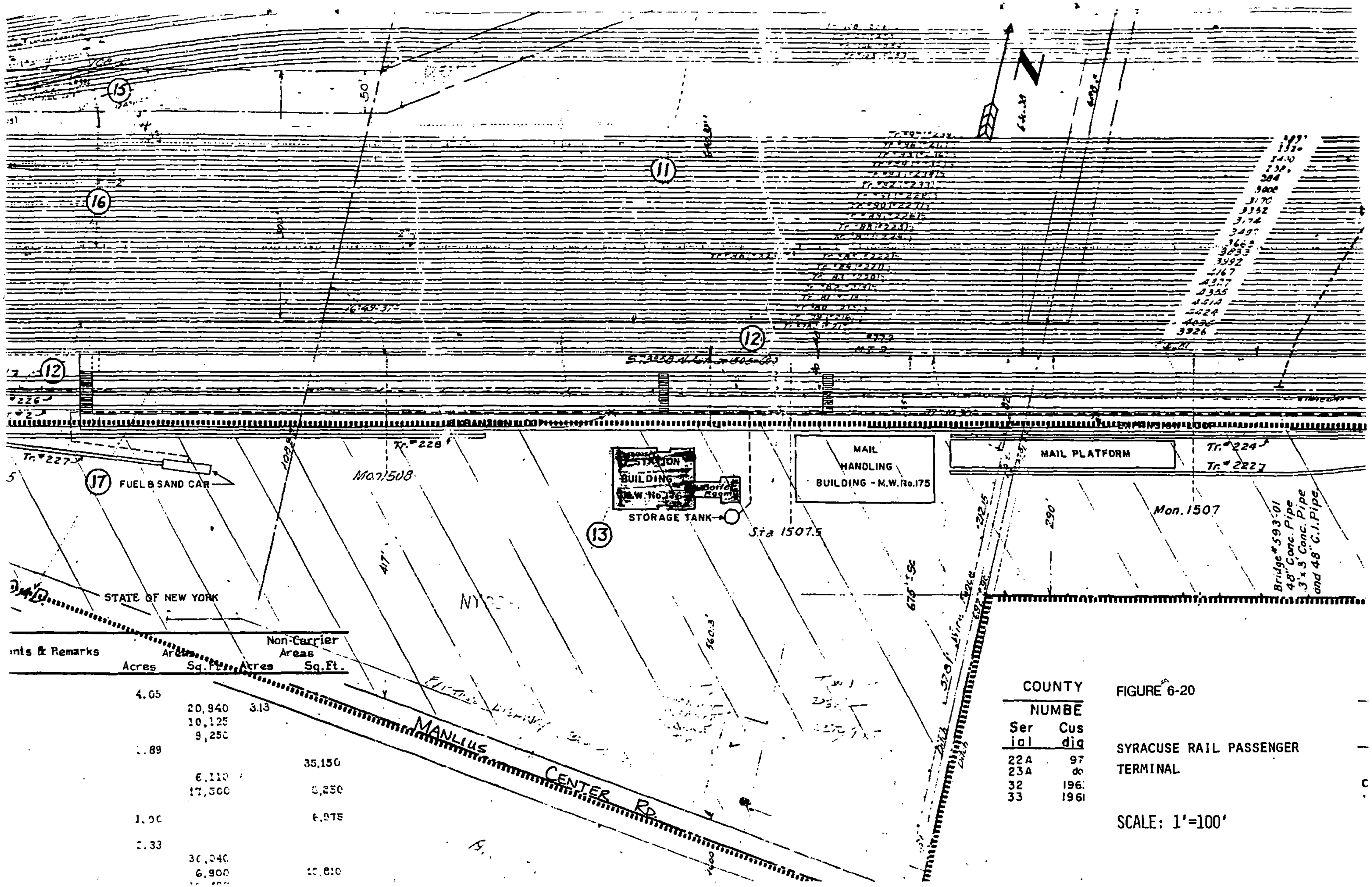
Amtrak's Syracuse station is located in the town of East Syracuse, adjacent to Conrail's Dewitt freight classification yard as shown on Figure 6-20. East Syracuse is located about 9.0 km (5.6 miles) east of downtown Syracuse, and the terminal is located about 122 m (400 feet) off East Manlius Center Road. Access to downtown Syracuse, Syracuse University and other points of interest is via Interstate 690. (Just west of its interchange with Interstate 481, Interstate 690 and the old New York Central mainline share the former right-of-way of the Erie Canal.) The current Amtrak terminal is poorly situated, has low public visibility, no extra amenities and is served by infrequent public transportation.

The one-story terminal is owned by Amtrak with accompanying trackage owned by Conrail (formerly the New York Central Railroad trackage). The two-track main line is tangent through the station area and has a center pocket track about 609.6 meters (2,000 feet long). The two low-level platforms are approximately 548 meters (1,800 feet) long.

The Greyhound bus terminal is located at Erie Boulevard, just east of the Interstate 690 / Interstate 81 interchange. This location is roughly 1.6 km (1 mile) from downtown Syracuse. The three-story facility is the old New York Central Railroad terminal building and was constructed in the Art Deco style of architecture popular in the '20's and '30's. The facility was converted to its present use in 1962 when the railroad was relocated around the north side of town to make room for construction of Interstate 690. The terminal today is in a state of disrepair, and in urgent need of improvement. Alterations completed in 1962 detract from its original architecture, but the facility is eligible for the National Register of Historic Places. An abandoned rail platform still remains underneath the elevated I-690 structure.

Corridor Characteristics

The former New York Central railroad corridor is rather straight through the Syracuse metropolitan area. The old alignment paralleled the Erie Canal (near



...nts & Remarks	Areas Acres	Sq.Ft.	Non-Carrier Areas Acres	Sq.Ft.
	4.05			
		20,940	3.13	
		10,125		
		9,250		
	1.89			
				35,150
		6,110		
		17,500		5,250
	1.00			6,975
	2.33			
		30,040		
		6,900		10,810

COUNTY NUMBE Serial	Cus dig
22A	97
23A	do
32	196
33	1961

FIGURE 6-20

SYRACUSE RAIL PASSENGER TERMINAL

SCALE: 1'=100'

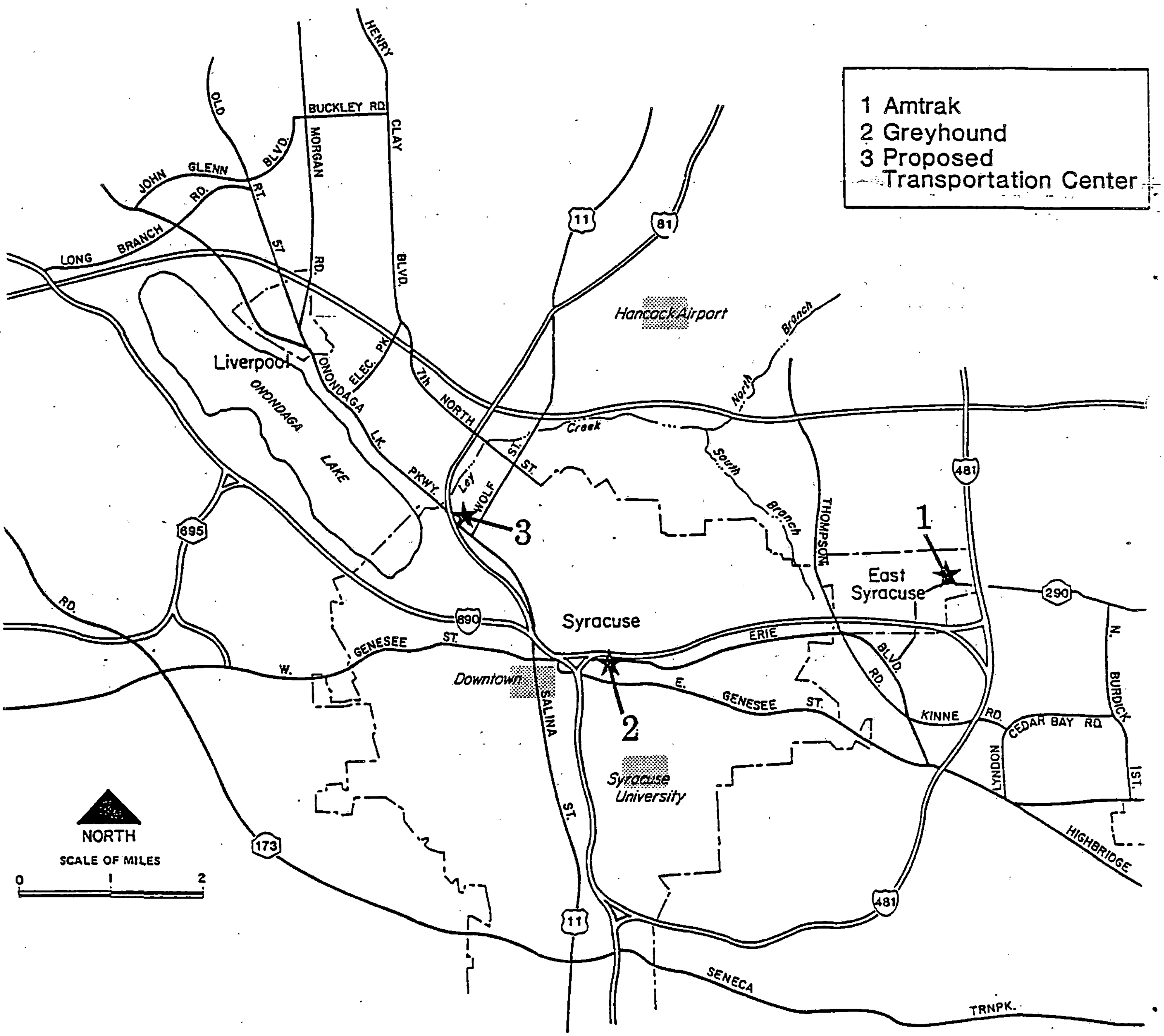
the present day Thompson Road/I-690 interchange) through downtown Syracuse and around the southern end of Onondaga Lake. In 1962, the main line was relocated around the north side of town for the I-690 construction and the Amtrak facility was moved from downtown to East Syracuse. The relocated corridor follows a more circuitous route through Syracuse, connecting with its original alignment at the southern tip of Lake Onondaga - about 4.8 km (3 miles) west of downtown Syracuse. The remaining corridor is relatively tangent with large-radii curves, and is fairly well suited for high speed operation.

Future Plans

Realizing that the present Amtrak facility is not well suited as a future multimodal facility, the Syracuse Metropolitan Transportation Council examined the feasibility of constructing a multimodal transportation terminal on Park Street adjacent to the relocated double-track Conrail mainline (see Figures 6-21 and 6-22). This proposed site is owned by the CNY Regional Market, a center for the wholesale and retail produce market for over 50 years. The Regional Market site is situated in a planned redevelopment area, and is located on the other side of I-81 from Carousel Center, a $150-million retail shopping mall. It is also adjacent to MacArthur Stadium, home of the AAA Syracuse Chiefs baseball team, and has good access to the interstate highway system and Syracuse-Hancock International Airport. A new road into the site would improve access from the interstate highway and street network. The total cost of the facility is estimated to be $7.2 million, excluding right-of-way acquisition. A tourist train operation is also planned for the Erie Boulevard Corridor west of downtown. This operation would serve the developing Franklin Square and Armory Square areas, and then would turn south and travel adjacent to the south of downtown and Syracuse University areas.

Implementation Issues

The corridor, for the most part, is fairly well suited for higher speed operation. Numerous grade crossings both east and west of downtown Syracuse would have to be eliminated, and some curves would have to be smoothed out.

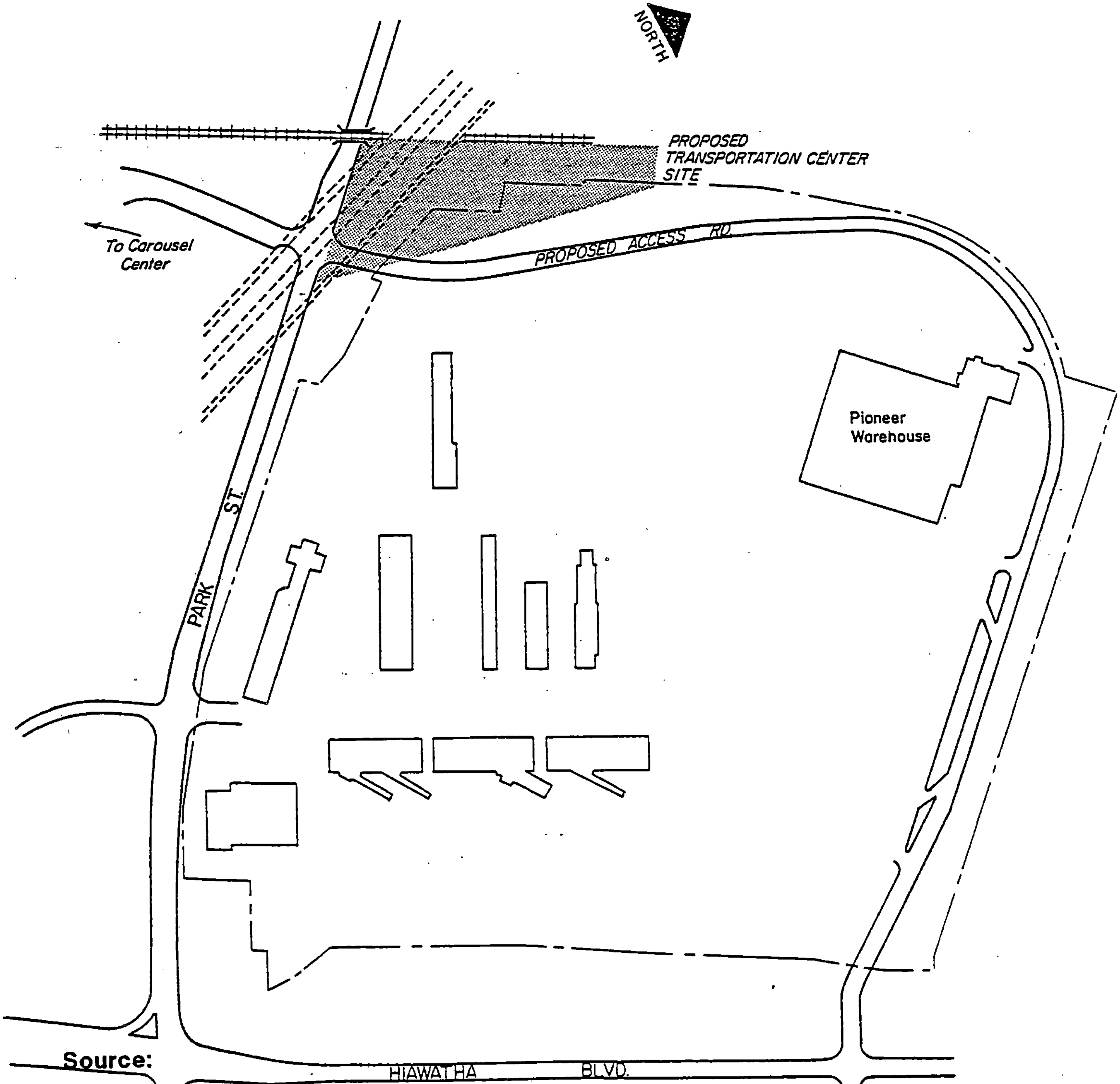


Source:
SMTC's Transportation Center, Feasibility Study for the Park Street Location, January 1991

FIGURE 6-21

Proposed Syracuse Transportation Center

Figure 9. Proposed Transportation Center site in relation to other areas



Source:
SMTC's Transportation Center, Feasibility Study for the Park Street Location, January 1991

FIGURE 6-22

Proposed Transportation Center Site in Syracuse

Figure 1. Location of Proposed Transportation Center at the Regional Market

The proposed multimodal facility at Park Street is "an idea whose time has come"; however, there are some reservations about its lack of proximity to downtown and the University. If the old New York Central Railroad tracks had not been relocated, the proposed location for a new multimodal facility would probably be downtown. It would be prudent at this point to evaluate the possibility of a high speed transportation system sharing the Erie Canal / New York Central Railroad / Interstate 690 right-of-way. This right-of-way is more centrally located and would better serve the downtown and University areas. Although this right-of-way is rather tight, the adjacent land use does not appear to be extremely valuable, consisting of low-rise industrial/commercial facilities. Of special interest would be the possible reuse of the Greyhound (old New York Central Railroad) terminal for future high speed service.

6.10 Albany

Description of Existing Transportation Terminals

This intercity rail passenger station is located on East Street in Rensselaer, across the Hudson River from downtown Albany. The station is located on relocated Conrail main line, and is owned and operated by Amtrak. The 3-track main line separates 2 low-level platforms that are 198 meters (650 feet) and 287 meters (940 feet) long, as shown on Figure 6-23. The Rensselaer terminal was expanded twice in the '80's, is well patronized and is served adequately by bus and train service into Albany.

The railroad terminal for the metropolitan Albany area used to be located in Albany Union Station, at the corner of Broadway and Pine Streets in downtown Albany. Another railroad bridge crossed the Hudson River at this point to connect with trackage in Rensselaer, but construction of Interstate 787 in the mid to late '60's forced the demolition of the railroad bridge and associated terminal trackage and the relocation of the railroad terminal to Rensselaer. (Albany Union Station was renovated and is now the Fleet Norstar Bank.) There exists one railroad bridge across the Hudson River connecting Albany and Rensselaer.

Corridor Characteristics

The Conrail railroad corridor located on the east side of the Hudson River from New York City has been upgraded to Class 6 track, and is approved for speeds up to 176 kph (110 mph). The corridor passes through the Rensselaer Station and crosses over the Hudson River into Albany. The railroad passes over the remaining Delaware & Hudson (D&H) trackage at this point, and has a connection to the D&H. Double trackage of the old D&H remains in the median of I-787 south of this connection and serves the Port of Albany located about 2.4 km (1.5 miles) south of downtown Albany. As it passes north of downtown Albany, the corridor is a little "curvy" and generally parallels the I-90 freeway. At the I-90 / Everett Road interchange, the railroad corridor becomes much straighter with large-radii curves connecting the tangent segments.

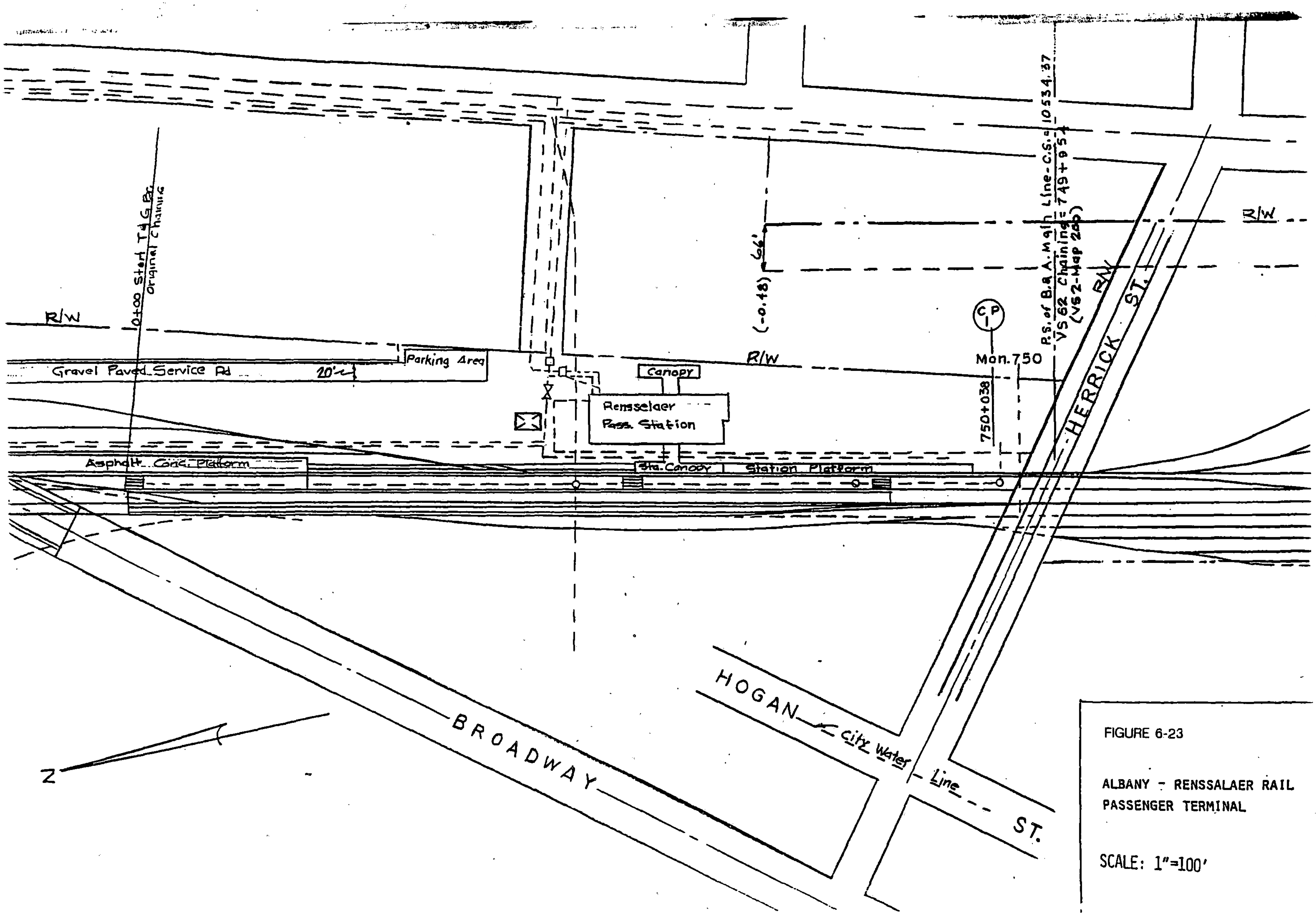


FIGURE 6-23

ALBANY - RENSSALAER RAIL PASSENGER TERMINAL

SCALE: 1"=100'

Future Plans

Plans are being discussed now to relocate the Amtrak rail terminal to the west side of the tracks at Rensselaer, linking it with a proposed mixed use development on the riverfront. This relocation activity is being viewed as an opportunity to develop a new intermodal station in Rensselaer, and conceptual plans are being developed for future discussion. In a related activity, a study to improve the linkage between the Rensselaer terminal and Albany County Airport will be forthcoming.

In other high speed transportation studies in the Albany area, possible sites for an intermodal facility on the west side of the river are also being investigated. Years ago, a planned mixed-use development was proposed for the former Tobin-First Prize meat packing plant at the northwest quadrant of I-90 and Everett Road. This proposed development would have also included an intermodal transportation facility, but did not come to fruition. Another undeveloped site in the I-90/Everett Road vicinity has recently been investigated for a similar transportation facility, however, this proposal has not yet gathered necessary support.

Implementation Issues

The corridor for the most part meets Class 6 track standards, and as such is one of the best railroad corridors in the country. Consequently, it is well suited for higher speed operation. With regard to the best location for an intermodal facility, the debate continues. It would be possible to leave the terminal in Rensselaer, which is directly across the Hudson River from downtown Albany and has good bus and taxi connections into the city. Only time will tell if any of the other locations being discussed garner support.

6.11 New York City

Description of Existing Transportation Terminals

New York City has two major rail passenger terminals - Pennsylvania Station and Grand Central Terminal (GCT). GCT is primarily a suburban commuter rail station serving the northern suburbs while Penn Station serves both suburban commuters and intercity passengers. Penn Station is on the highly successful Northeast Corridor, and for the purpose of this high speed intercity study, will be the focus of our initial investigation.

Penn Station is located at 7th Avenue between West 31st and West 33rd Streets in downtown Manhattan (see Figure 6-24). Both the station and associated trackage are owned and operated by Amtrak. A $198-million Penn Station Improvement Project was begun in November 1991, and is expected to be completed in 1995. This project will dramatically improve pedestrian flows through the extremely busy terminal, adding new elevators, escalators, stairways and a glass-towered entranceway while improving the climate conditioning systems. Penn Station provides connections to the New York City Transit Authority (NYCTA), Long Island Railroad, New Jersey Transit, Port Authority Trans-Hudson, and Amtrak operations.

The station has a total of 21 tracks (17 double-ended and 4 stub-ended) served by 11 high-level platforms which range from 195 meters (640 feet) to 451 meters (1480 feet) in length. The station trackage has a maximum curvature of 12° 30', and uses No. 8 turnouts. (There is a wye track located at the west end of Penn Station called the Empire Connection that has a 22° 00' curve, and is presently being used by Amtrak for northbound trains to Albany - Rensselaer.) Both 11,000-volt AC catenary and 600-volt DC contact rail traction power systems are present at Penn Station.

Corridor Characteristics

The station is accessed from the east by the twin 2-track tunnels under the East River, and from the west via a single 2-track tunnel located under the Hudson River. This 2-track tunnel under the Hudson River and the 4-track tunnel under

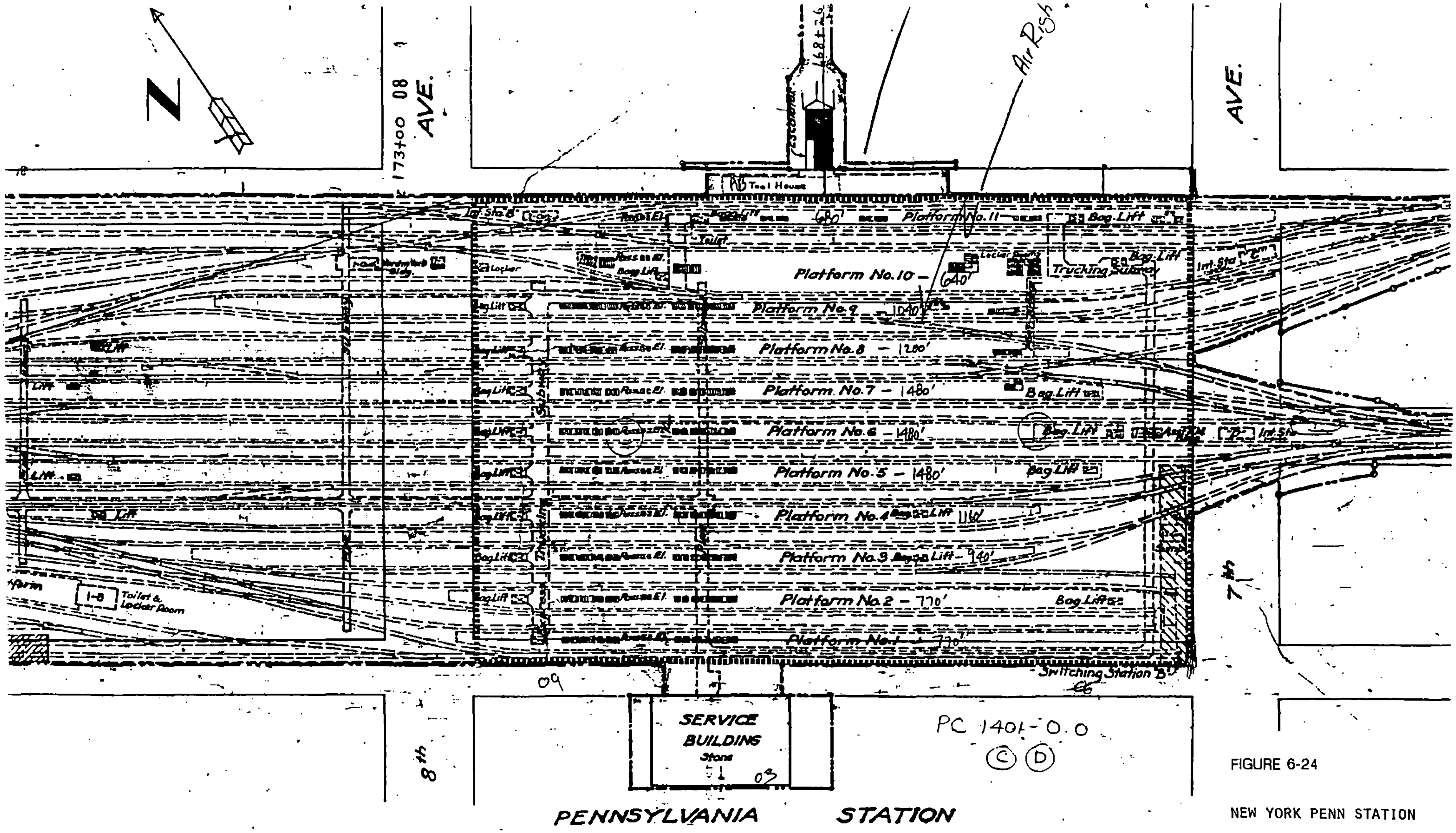


FIGURE 6-24

NEW YORK PENN STATION

SCALE: 1"=100'

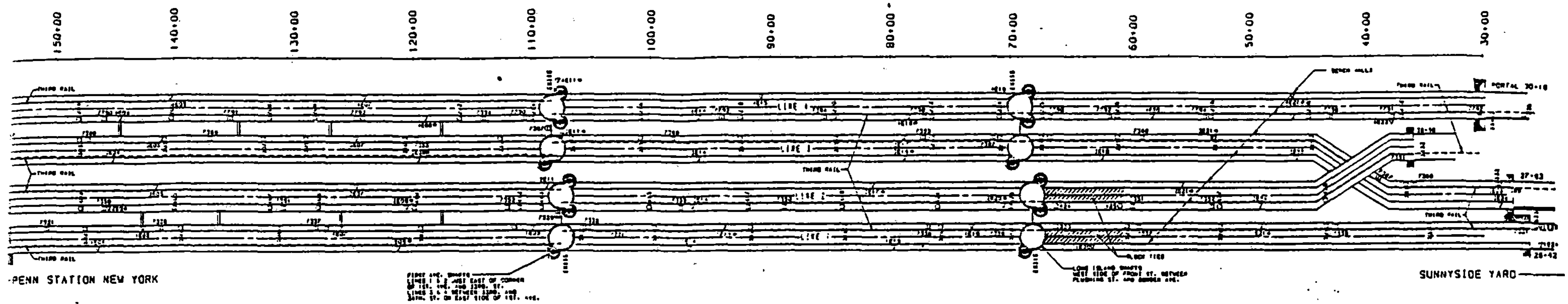
the East River are part of the relatively high-speed Northeast Corridor, as shown on Figure 6-25. (Amtrak is spending $28-million to improve high speed operation in the Penn Station area and its associated tunnels, as well as in Boston's South Station.) The typical section defines a horseshoe tunnel with a maximum width of 3.56 meters (11'-8") and a maximum height above the top of rail of approximately 4.57 meters (15 feet) to a 11,000-volt catenary wire. However, the Hudson River tunnel is only 3.35 meters (11'-0") wide, limiting the maximum vehicle width to 3.2 meters (10'-6"). This vehicle width allows only 7.6 cm (3 inches) of clearance on either side of the vehicle, which is sometimes not enough. It may be possible to widen these tunnels somewhat by removal of a walkway, but additional investigation of this option is necessary. The minimum catenary wire height is 4.62 meters (15'-2"), as documented in field inspection reports dated July and October 1991.

The 11,000-volt AC catenary system requires a minimum clearance of 15.2 cm (6") to the top of any vehicle, setting the maximum height of a rail vehicle at 4.47 meters (14'-8"). (A telephone conversation with Amtrak's Senior Engineer of Clearances and Tests puts this minimum wire height at 4.60 meters (15'-1"). However, he believes a minimum clearance of only 12.7 cm (5") is needed, leaving the maximum vehicle height unchanged at 4.47 meters (14'-8").)

Penn Station is accessed from the north (i.e., from Albany) along the Westside Corridor. As one travels south into the city, this 16 km (10 mile) long corridor begins as it departs the Metro - North Railroad corridor along the east shoreline of the Hudson River at Spuyten Duyvil. It then continues in a totally grade-separated fashion into Penn Station, a total of 14.4 km (9 miles) of double track and 1.6 km (1 mile) of single track. As the corridor approaches Penn Station from the north and west, it negotiates the extremely tight Empire Connection.

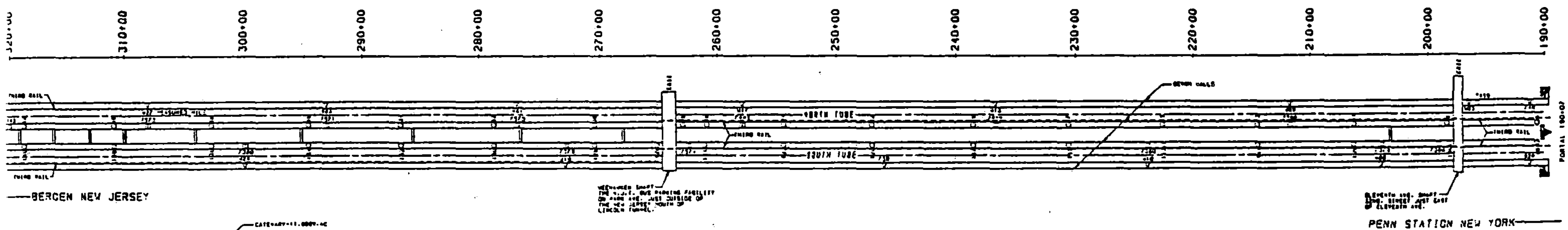
Future Plans

One planned improvement on the New Jersey side of the Northeast Corridor is improved access to the Newark International Airport from the Northeast Corridor. The Northeast Corridor passes within 1.6 km (1 mile) of the airport terminal on its way to Newark Penn Station, where one must transfer to a shuttle bus to access



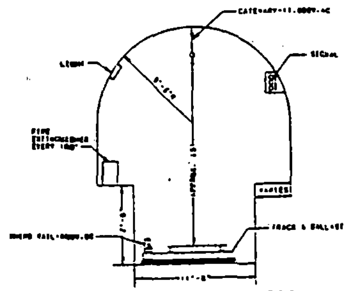
EAST RIVER TUNNELS

SCALE 1" = 400'



NORTH RIVER TUNNELS

SCALE 1" = 400'



TYPICAL CROSS SECTION

SCALE 1" = 8'

NOTES

1. FIRE EXTINGUISHERS ARE EVERY 100 FT. ON ALTERNATING SIDES OF THE BENCHWALL EACH PROVIDED WITH A 50 FT. HOSE.
2. PROVIDED IN EACH TUNNEL IS A COAX RADIO ANTENNA.
3. DRY STANDPIPE LOCATIONS FROM 1ST. AVE. SHAFT ARE EAST AND WEST FOR 150 FT. IN EACH DIRECTION. LOCATED ON THE SOUTH WALLS OF LINES 1 & 3 AND ON THE NORTH WALLS OF LINES 2 & 4.

FIGURE 6-25

NORTH AND EAST RIVER TERMINAL

SCALE: 1'=800'

Amtrak

Office of the Chief Engineer

NEW YORK NORTH AND EAST RIVER TUNNELS NEW YORK

UTILITY LOCATIONS

X-0

the airport. There are discussions of constructing a new station adjacent to the airport, and perhaps connecting the Newark Airport people mover system (now under construction) to the new station.

Implementation Issues

From a physical feasibility framework, it would be possible to bring a maglev vehicle into Penn Station, taking into account the above-discussed clearance requirements. However, Penn Station suffers from an existing capacity limitation. If one train is added to the schedule, then another must be removed. Capacity studies at Penn Station have been on-going for some time, with no apparent solution. This operational issue must be addressed adequately before serious consideration can be given to utilizing Penn Station as a future maglev terminal. If maglev access into Penn Station is not possible for some reason, an alternative transfer station outside the city would have to be evaluated.

6.12 Pittsburgh

Description of Existing Transportation Terminals

At one time, Pittsburgh had three (3) downtown railroad terminals:

- Pennsylvania Station
- Baltimore & Ohio (B&O) Station
- Pittsburgh & Lake Erie (P&LE) Station

Today, only one of the three remains in railroad operation. The P&LE Station was converted to a popular restaurant / entertainment complex called Station Square. It is across the Monongahela River from downtown Pittsburgh, however, it has easy access into downtown via the Port Authority Transit of Allegheny County's (PAT) LRT system. The B&O Station served as the terminal to the commuter rail system which operated until a few years ago, and today stands empty. Penn Station is the sole survivor, and is located at the northeast corner of Liberty and Grant Streets in downtown (see Figure 6-26). It is owned and operated by Amtrak. Trackage from Cleveland and Philadelphia is owned by Conrail and trackage from Chicago and Washington, D.C. is owned by the CSX. The station consists of 15 tracks on elevated structure and retained fill - 5 stub-ended and 10 double-ended tracks. Seven low-level platforms serve the 15 terminal tracks, accessed via passenger tunnels located beneath the tracks. Five (5) of the double-ended tracks are located on 12^{0} 30'curves, approaching the station from the northwest after crossing the Allegheny River and 11th Street. These 5 tracks contain station platforms which are on the 12^{0} 30' curves for almost half of their 396 meter (1300 feet) length. A series of complex turnouts (i.e. double slip switches) are located at 'BU' Tower, just east of Penn Station. The station can accommodate both single-level and bi-level commuter rail vehicles, and at first glance, appears to be suitable for higher-speed maglev technology.

The LRT system crosses the Monongahela River after leaving Station Square and enters a railroad tunnel which travels north beneath downtown Pittsburgh. The

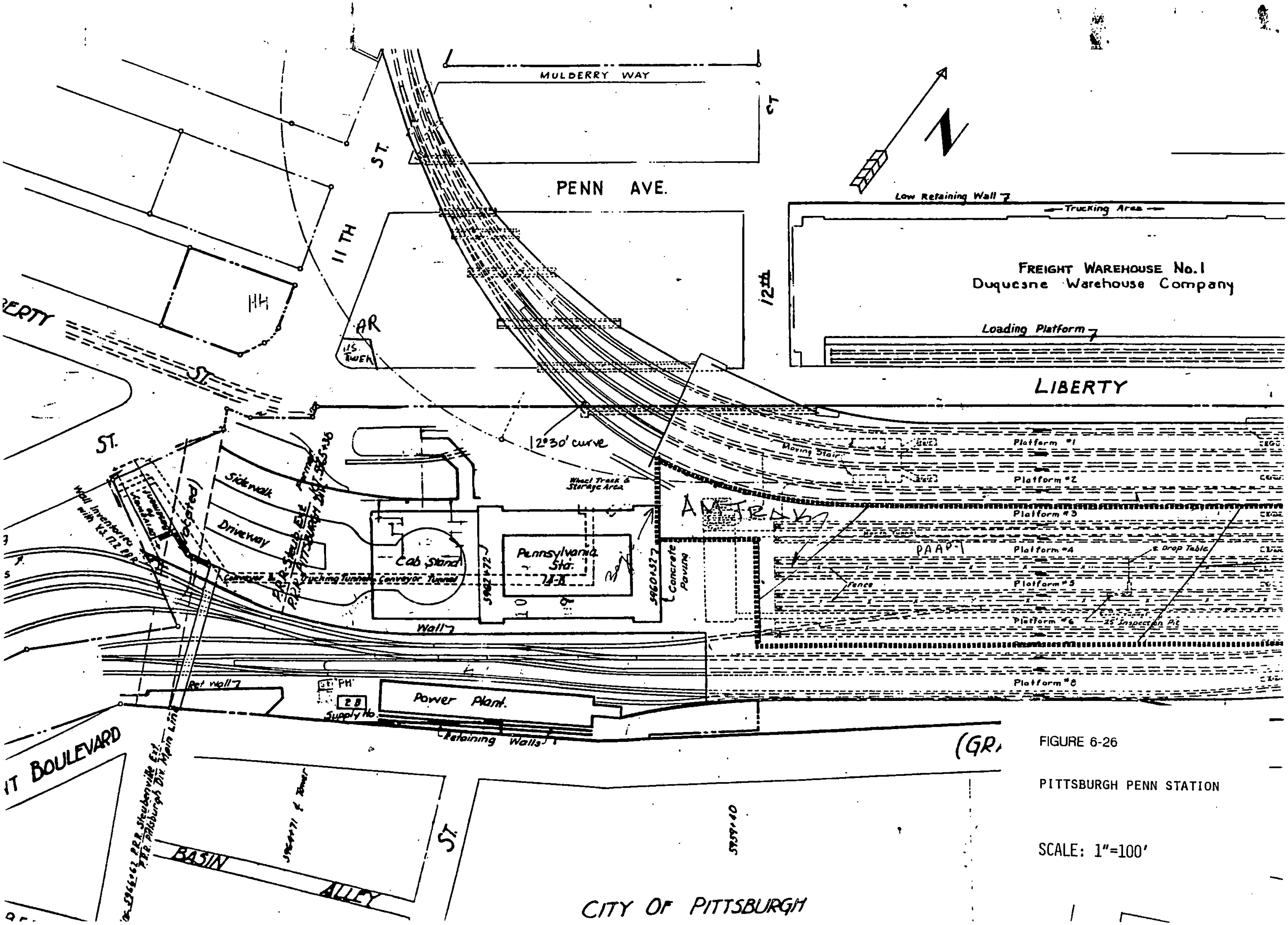


FIGURE 6-26

PITTSBURGH PENN STATION

SCALE: 1"=100'

tunnel splits at Grant Street, part of which emerges at Penn Station. The remaining tunnel travels under 6th and Liberty Streets to serve three subway stations. One LRT train shuttles back and forth between Penn Station and Steel Plaza Station, where the two tunnels diverge.

Corridor Characteristics

The hilly topography of the Pittsburgh metropolitan area creates a difficult climate for high speed operation. The regional is well served with numerous railroad corridors; however, steep grades and tight curves will be difficult to overcome without expensive structures.

Future Plans

In February 1990 a consortium of firms completed a feasibility study for a proposed maglev system linking the Greater Pittsburgh International Airport to downtown Pittsburgh. This feasibility study investigated a total of four different alignments for the proposed 30.4 km (19 mile) system, which would terminate at either Allegheny Center, the B&O station or Station Square (see Figure 6-27). The construction cost estimates for the project ranged from $299 million to $648 million, and the consortium is lobbying for federal assistance at this point.

Implementation Issues

As stated earlier, the hilly topography of the Pittsburgh metropolitan area creates a difficult climate for high speed operation. The topography can be overcome by maglev technology much better than with steel rail / steel wheel technology; however, the cost of implementation in Pittsburgh must be weighed against probable costs in other metropolitan areas. Penn Station could serve as a future maglev terminal.

FIGURE 5
MAGLEV Demonstration Project
Alternate Schemes

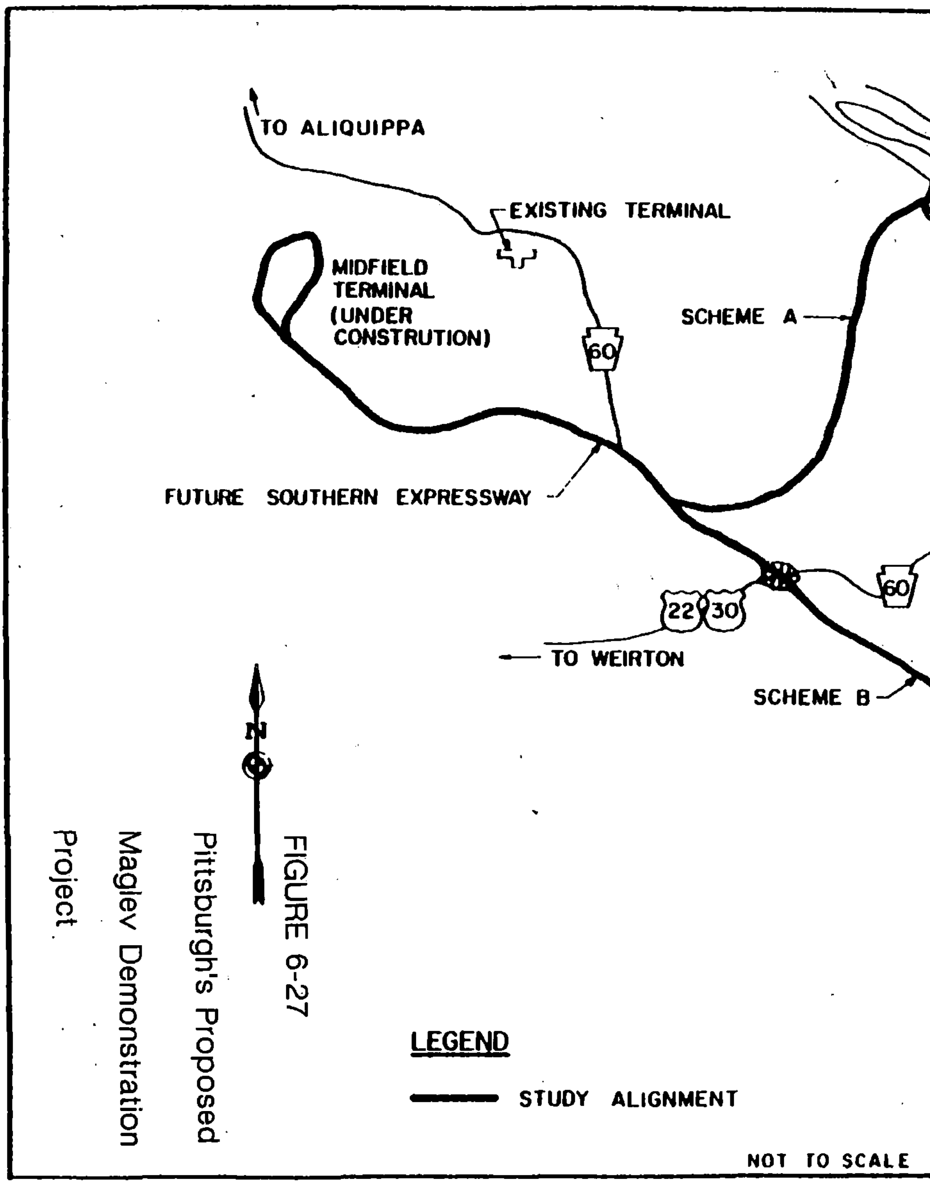
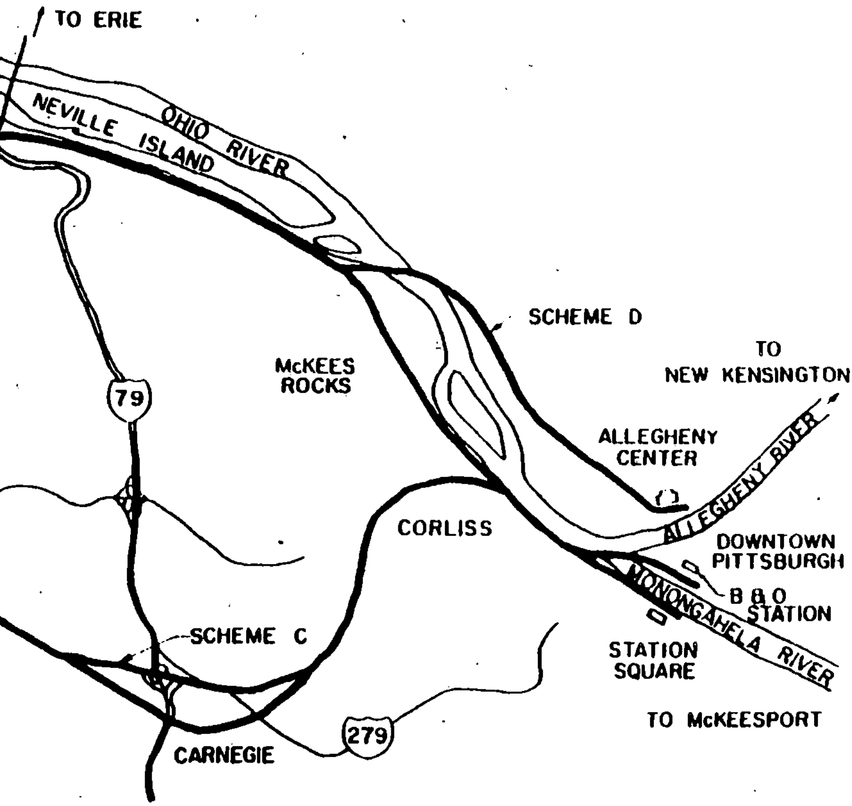


FIGURE 6-27
Pittsburgh's Proposed Maglev Demonstration Project



Source:
Report of the Preliminary Feasibility Study of the Pittsburgh MAGLEV Project, February 1990

MAGLEV DEMONSTRATION PROJECT
ALTERNATE SCHEMES

6.13 Philadelphia

Description of Existing Transportation Terminals

There are three rail passenger terminals located in Philadelphia - the Market-East Station located on Market Street between 11th and 12th Streets, the Penn Center Suburban Station located at 15th and Market Streets and the 30th Street Station located at 30th and Market Streets. Since the 30th Street Station is the only station that accommodates both suburban commuters and intercity passengers, it will be the focus of our initial investigation. (See Figures 6-28 and 6-29.)

The 30th Street Station and adjacent trackage is both owned and operated by Amtrak. It is a two-level station located just west of the Schuylkill River. The top level consists of 6 double-ended tracks running in an east-west configuration. This level is used for all Southeastern Pennsylvania Transportation Authority (SEPTA) suburban lines as well as the heavy rail transit line which serves the Philadelphia International Airport. Three continuous high-level platforms, ranging in length from 320 meters (1,050 feet) to 369 meters (1,210 feet), serve the upper level trackage. The maximum curvature used on the upper level is 12° 30'. The bottom level consists of 19 double-ended tracks running in a north-south configuration constituting a portion of the Northeast Corridor. The relatively high-speed intercity rail service from New York to Washington utilizes this trackage, which is powered by a 12,500-volt AC catenary system. Nine high-level platforms serve the lower level of the terminal, ranging in length from 293 meters (960 feet) to 323 meters (1,060 feet). The maximum curvature found on the lower level was 6°45'.

The minimum height of the catenary wires was measured in August 1990 at 4.85 meters (15'-11") above the top of rail along Track No. 10. The low wires on Tracks No. 3,7 and 9 were measured at 4.88 meters (16'-0") above top of rail. For this reason, only single level commuter rail equipment is permitted at 30th Street Station.

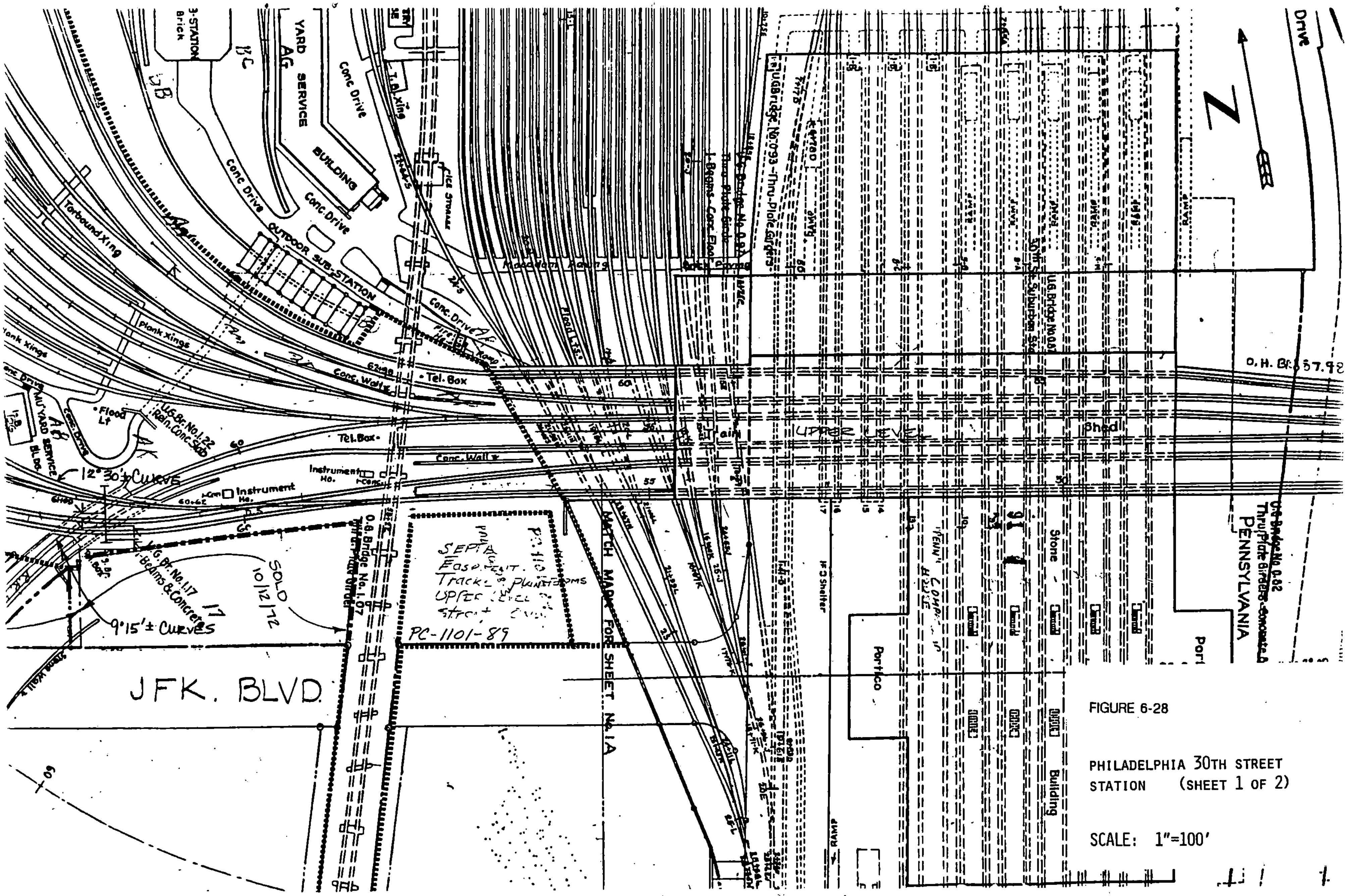


FIGURE 6-28

PHILADELPHIA 30TH STREET STATION (SHEET 1 OF 2)

SCALE: 1"=100'

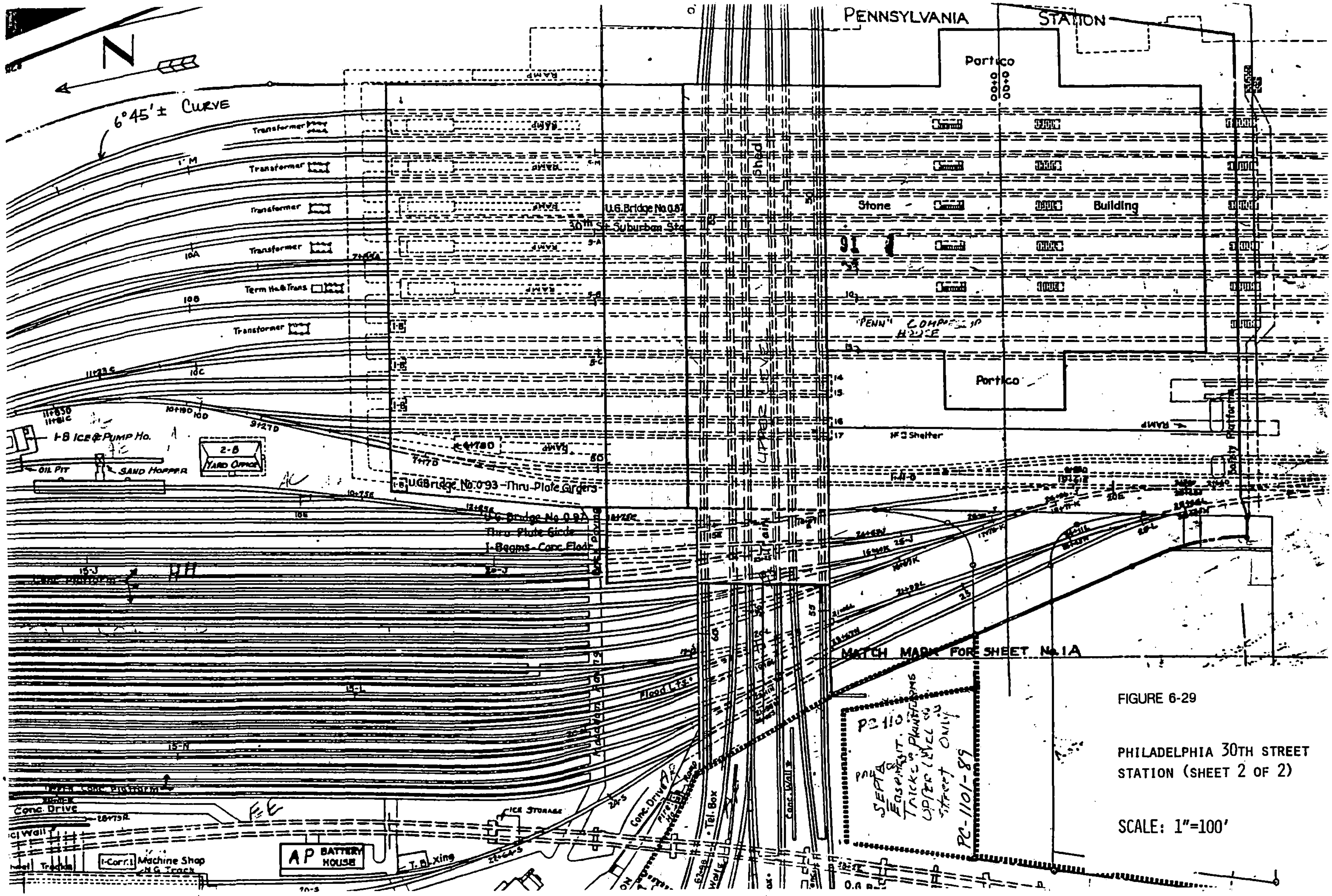


FIGURE 6-29

PHILADELPHIA 30TH STREET STATION (SHEET 2 OF 2)

SCALE: 1"=100'

Corridor Characteristics

The Northeast Corridor serves the 30th Street Station, and as such, is totally grade separated through the Philadelphia metropolitan area. Most of this trackage is certified for 200 kph (125 mph) operation.

Future Plans

Conceptual plans for a redevelopment program at the 30th Street Station have been prepared. This development program would include such elements as:

- additional office development;
- rehabilitation of the existing 30th Street Station building;
- a possible "low-end sector" hotel project ;
- a festival marketplace that would include restaurants and a wide range of retail shops; and
- additional parking.

Implementation Issues

The 30th Street Station appears to be ideally situated for use as a future maglev terminal. It has no parallel in efficiently combining intercity, urban and suburban transportation modes in the greater Philadelphia area, and appears large enough to have excess capacity at this time. The Northeast Corridor is perhaps the best corridor in the nation for further improvement to higher speed operation. However, adjacent land use could constrain these future improvements and must be weighed against other alternatives and factors such as capacity, patronage and environmental impacts among others.

6.14 Boston

Description of Existing Transportation Facilities

Three commuter rail stations operate in downtown Boston - North Station, Back Bay Station, and South Station. Both the Back Bay and South Stations accommodate suburban and intercity rail service, as well as the heavy rail system. For this study, however, South Station appears to be the most compatible terminal and will be the focus of our initial investigation.

The South Station Transportation Center is located on the southwest corner of Atlantic Avenue and Summer Street (see Figure 6-30). The transportation center underwent an extensive renovation in the late 1980's, transforming an antiquated rail passenger terminal into a multimodal center that integrated commuter and intercity rail systems, rapid transit, intercity and intracity bus service and automobile parking facilities. This $81.4 million project is expected to be complete in 1994. These services also include a bus connection to the Logan International Airport. The Center is owned by the Massachusetts Bay Transportation Authority (MBTA) and trackage is owned by both MBTA and Conrail.

The station consists of 11 new stub-ended tracks oriented in a northeast-southwest configuration. (Figure 6-30 is an old plan which shows a total of 32 tracks.) The 11 stub-ended tracks are served by new high-level platforms, ranging from 198 meters (650 feet) to 323 meters (1,060 feet) in length. Electrification via an overhead catenary system is being designed for implementation at South Station as part of the $150-million New Haven to Boston electrification project. Bi-level equipment was recently placed in service at the terminal by the MBTA. The Red Line rapid transit system, located in Summer Street, can be accessed directly from the South Station Center. The maximum curvature found in the terminal area is located just south of the station as the 4-track main line begins to turn west on the old Boston & Providence Railroad right-of-way, and is believed to be approximately 8^{0} 00'. A series of 12^{0} 30' curves in the same vicinity serves freight trackage parallel to Atlantic Avenue.

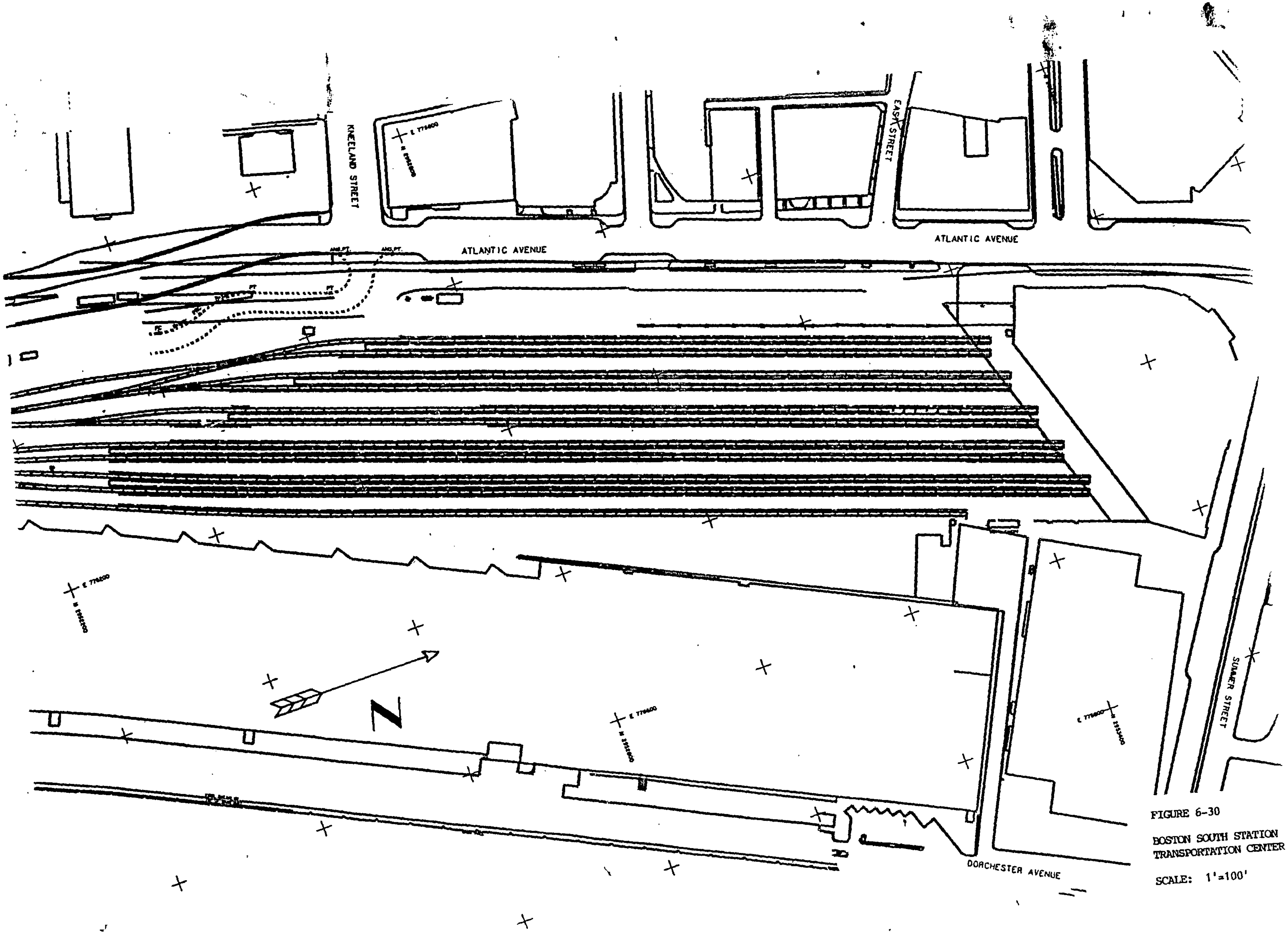


FIGURE 6-30

BOSTON SOUTH STATION TRANSPORTATION CENTER

SCALE: 1'=100'

Corridor Characteristics

As one approaches Boston from the south, the railroad corridor has long tangent segments connected with large-radii curvature. However, there are numerous grade crossings in the corridor until one gets much closer to downtown Boston. The New Haven to Boston electrification project will include track improvements, alignment modifications and some grade separations that begin to prepare the total corridor for eventual 240 kph (150 mph) service. Amtrak is spending another $28 million for additional high speed improvements in South Station, as well as at New York's Penn Station. The corridor is adjacent to numerous activity centers such as Harvard Medical School, Northeastern University, Fenway Park and the Boston University and New England Medical Centers.

Future Plans

At this time, this study team is unaware of any other future plans that might affect the implementation of high speed transportation into the Boston metropolitan area.

Implementation Issues

The unparalled intermodality present at the South Station Transportation Center, coupled with the on-going improvements on the New Haven to Boston corridor, makes this an ideal location for a future maglev terminal.

6.15 Washington D.C.

Description of Existing Transportation Terminals

Union Station in Washington D.C. is the intercity and commuter rail terminal for that city, and is located on Massachusetts Avenue between First and Second Streets. (See Figure 6-31). Amtrak owns and operates Union Station, while both Amtrak and Conrail own trackage north and south of the station. The station underwent an extensive, and award-winning, renovation in the 1980's, and is the southern terminal for Amtrak's successful Northeast Corridor service. It also accommodates intercity service to the western and southeastern United States.

The station consists of 30 tracks - 21 stub-ended tracks and 9 double-ended tracks which run in subway beneath Massachusetts Avenue and connect to Conrail's existing railroad corridor on the south side of downtown Washington. The terminal trackage is served by a total of 18 platforms in both high-level and low-level configurations. The platforms vary in length from 500 feet to 1,440 feet. About two dozen slip switches control movement from Union Station to the 10 tracks which cross over Florida Avenue. No. 8 turnouts are used along with maximum 12^0 30' curves. An overhead catenary system is in use, limiting equipment type to single-level vehicles only.

A Washington Metropolitan Area Transit Authority (WMATA) subway station is connected to the west side of Union Station, and the commuter rail operation from Baltimore (Maryland Rail Commuter) is considered one of the fastest growing commuter rail services in North America. Virginia Railway Express (VRE) has started two new commuter rail lines to Manassas and Fredericksburg in Northern Virginia which now terminate in Union Station. Amtrak is operating and maintaining the service for VRE.

Corridor Characteristics

The railroad corridor which proceeds north from Union Station is on the Northeast Corridor. As a result, the corridor is totally grade-separated and trains are certified for 200 kph (125 mph) operation. Adjacent land use is somewhat

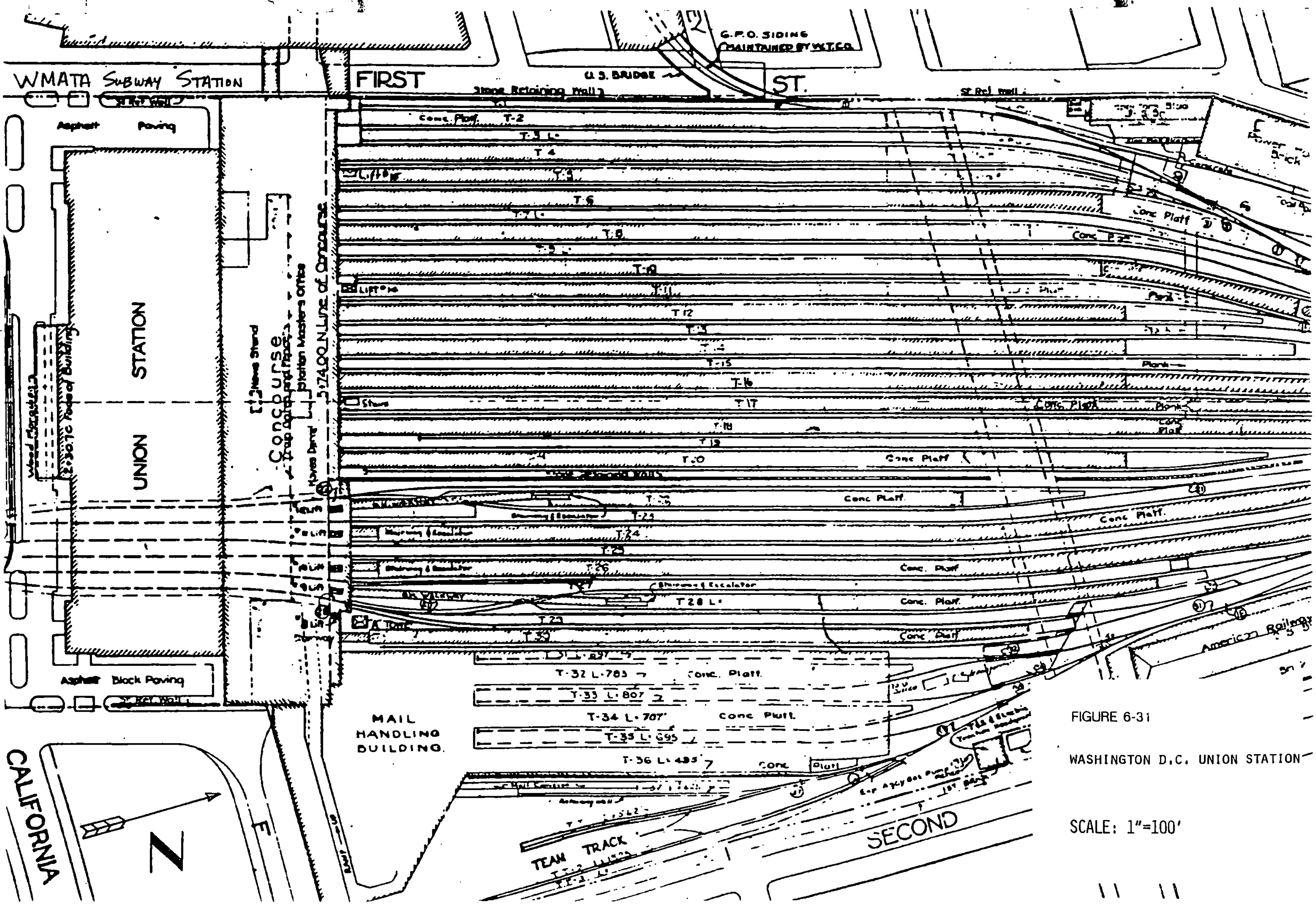


FIGURE 6-31

WASHINGTON D.C. UNION STATION—

SCALE: 1"=100'

dense and includes Gallaudet College, the University of Maryland and the Baltimore-Washington Airport.

Future Plans

Studies are being initiated for the possible extension of the Northeast Corridor south from Washington, D.C. into the states of Virginia and North Carolina. The planned project would eventually include the construction of grade separations and alignment modifications, along with track reconstruction, that has the potential to dramatically increase railroad ridership into the Capital from these areas.

Implementation Plans

This unique mix of transportation modes and relatively high speed corridors makes Union Station a prime candidate for future maglev operations. The relatively dense land use in the corridor could constrain future high speed improvements somewhat, and must be weighed in the future against other alternatives with differing impacts.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The PB Team surveyed the physical and operational characteristics of four existing and planned maglev systems pertinent to the intermodal interface for each system. The maglev systems investigated include:

- Grumman "New York State" (Configuration 002) Maglev
- Transrapid Intercity (Transrapid 07) Maglev
- HSST Passive Intermediate Speed (HSST-300) Maglev
- Japan Railways Vertical Magnet (Configuration MLU 002) Maglev

These systems characteristics were evaluated and addressed such issues as:

- Type of levitation
- Guideway requirements for carrier entry, levitation and propulsion (This information would be used to evaluate the feasibility of transporting maglev vehicles in some fashion over existing railroad tracks, i.e., in a "piggy-back" mode.)
- Vehicle dimensions
- Limiting route alignment
- Loaded vehicle weight
- Height of door sill, door configuration
- Maximum train length
- Method of coupling
- Operational characteristics at slow speed
- Supporting structure when not levitated

- Levitation power requirements and sources
- Auxiliary power requirements and sources
- Vehicle dynamics stationary on carrier

A matrix displaying this information was prepared for each maglev system.

If these maglev systems are to be commercially and economically viable, they will have to access the centers of major metropolitan areas. The focus of this study was to investigate the feasibility of using existing railroad rights-of-way to access center-city terminals, in one of three possible methods:

- maglev vehicles travel over existing railroad tracks with the use of steel guide wheels and some means of exterior propulsion (e.g. locomotive power.) A modification of this alternative would be to construct a "dual-mode" (or "at-grade") guideway, essentially a maglev guideway outfitted with standard rails at gauge;
- maglev vehicles are transferred onto modified railroad flatcars and transported over existing railroad tracks with locomotive power; or
- new grade-separated maglev guideways would be constructed on existing railroad rights-of-way, either in an exclusive or shared right-of-way configuration.

As a result of using existing railroad corridors, certain mandated horizontal and vertical clearance requirements must be met. AREA clearance requirements were compared with those used by Amtrak for unrestricted operation on its nationwide system, with the finding that Amtrak clearance requirements were the most restrictive. This information was used to prepare a total of three summary clearance diagrams for maglev equipment. Because high platform configurations are assumed for maglev operation, the Eastern U.S. Summary Clearance Diagram was used to assess the compatibility of present and planned maglev technologies with existing railroad infrastructure around the country.

Each of the four maglev technologies were superimposed upon the Eastern U.S. Summary Clearance Diagram in two different modes of transportation - the "piggyback" and the "at-grade" modes. Their impacts upon the clearance diagram were evaluated, and advantages and disadvantages of each transportation mode were discussed.

The results of this preliminary feasibility analysis for the four maglev technologies and the two transportation modes were summarized with the finding that both the JR MLU 002 and the HSST-300 systems fit within the required clearance diagram. Both the HSST-300 and JR MLU 002 maglevs appear to be feasible in the "piggyback" mode, but only the JR MLU 002 might possibly work in the "at-grade" mode. The JR design has the significant advantage of being able, with minor modification, to run on existing rails on its own or to be accommodated on board a rail car carrier, but its development is at least ten years away and very little information was available during the course of the study on which to base meaningful conclusions.

At this time, the required clearance envelope for unrestricted operation on existing railroad corridors in the United States precludes use of the Grumman and Transrapid maglev systems in either the at-grade or piggyback modes due to their excessive width and wrap-around body designs. However, further investigation of individual corridors in the United States could identify facility and / or operational modifications that would permit use of these wider technologies to gain access to center city terminals.

As a result of the above discussion, the HSST-300 maglev technology was carried forward in this study for the investigation of a maglev-rail car carrier intermodal concept.

The maglev-rail car carrier intermodal concept would allow the selected HSST-300 maglev to transition from the high-speed maglev guideway to a modified rail car carrier for transport over existing corridors into center city terminals. Obviously, this transition location would be as close as possible to the terminal to minimize the travel time in the "piggyback" mode. This investigation showed that this transition process is technically feasible and can be achieved within a four-to-five minute time span with little or no passenger disruption. However, if this intermodal concept is furthered as a means of accelerating maglev implementation in the U.S., much more work would be necessary.

To assess the feasibility of maglev systems accessing existing center city terminals in the United States, information on 15 selected cities was reviewed. This information was further bolstered by telephone conversations with appropriate Federal, State and local officials, where special attention was paid to:

- the presence and location of existing transportation terminals and their effectiveness in serving the needs of the individual metropolitan area;
- the physical characteristics of the transportation corridors which serve those terminals;
- characteristics of adjacent land uses, and any proposed modifications;
- plans for major capital investment in transportation facilities (e.g., transit systems, multimodal facilities, major rehabilitation, etc.);
- restrictive horizontal and vertical clearances;
- horizontal curve radii;
- length and height of existing station platforms and the presence of platform gaps;
- characterstics of current operating equipment;
- presence of electrification and power pickup arrangements, if applicable; and
- present and future interfaces with other transportation modes.

At the same time, certain operational characteristics such as terminal and line ownership, existing traffic levels, timetables and other factors were evaluated as that information was made available.

The individual urban areas were described in terms of their existing transportation infrastructure and future transportation plans and the feasibility of implementing maglev systems in these areas was assessed. In assessing these individual urban areas, certain assumptions regarding the viability of certain corridors which access the central business districts were made. Much of the proposed corridor discussion assumes the shared use of existing railroad right-of-way, an important component of any future high speed transportation network. (A recent Martin Marietta study estimates that shared railroad right-of-way could represent about 77% of any future maglev system's route length required to penetrate center cities, as compared to about 17% for shared highway right-of-way.) Any proposed alignments that are addressed assumes acceptance of this shared right-of-way concept, and have not been discussed with the asset owners, adjacent land owners, city residents, environmental groups or appointed/ elected officials in the individual urban areas. Following are recommendations for those individual urban areas.

7.2 Recommendations

San Francisco

The existing CalTrain terminal at 4th and Townsend Streets does not serve the CBD well, as it is geographically distant and has limited intermodal capability. This deficiency is being addressed in the study for a possible new terminal, but the construction cost estimate for either of the three alternatives may delay implementation of this worthwhile project. In an associated matter, the planned alignment for this terminal relocation project would severely constrain speeds into and out of the CBD. Should the proposed terminal project be delayed, an alternative location for a terminal station could be at the San Francisco International Airport.

The CalTrain corridor to San Jose is well suited, for the most part, for higher speed operation. Numerous grade crossings would require separation and some curve smoothing would be desirable.

Los Angeles

LAUPT is centrally located in downtown Los Angeles and is fast becoming a true intermodal terminal. As such, it deserves further consideration as a future high speed transportation terminal. The access into and out of LAUPT is rather circuitous and would have to be improved for a future high speed (HS) system One question to be addressed in the near future will be LAUPT's ability to absorb future HS activity along with its present and proposed operations. The SPTC San Fernando corridor appears to be rather well suited for higher speed operation, but has numerous grade crossings that would require separation in some fashion.

San Diego

The old Santa Fe Depot is well located within downtown San Diego, and is also becoming a true intermodal terminal. The railroad corridor which accesses the terminal from the north is constrained by existing land use and topographical features, consequently speeds would have to be adjusted accordingly. North of State Highway 52, the Interstate 5 alignment should be followed until the railroad corridor once again parallels Interstate 5.

St. Louis

The city appears to be furthering a planned intermodal facility just west of Union Station, however, a re-examination of the Union Station site should be made. The old terminal has undergone a dramatic renovation and has a tremendous unused capacity for additional transportation infrastructure. Using Union Station as the future intermodal terminal would also negate the need for an additional Metro Link station at Jefferson Avenue. If possible, the existing MacArthur Bridge should be used to cross the Mississippi River.

Chicago

Union Station appears to be a natural choice for a future maglev terminal. There are no major physical restrictions, an extensive station renovation is being completed and the proposed Central Area Circulator project would provide easier interface with other activity centers and transportation modes. The SPTC/Amtrak/Santa Fe corridor which parallels the DesPlaines River appears to be well suited for higher speed technology. One area requiring further study would be the corridor's intersection with Conrail/NS trackage just south of the Chicago River. CUS' ability to absorb additional transportation operations would also require study.

Cleveland

The existing infrastructure and ambitious plans for Tower City Terminal make the terminal the restored focal point for intermodal transportation in Cleveland. The railroad alignments necessary for access to the terminal are more circuitous and will require extensive speed restriction. One primary focus of future study should be the improvement of these corridors for higher speed operation.

Buffalo

The existing Exchange Street Station is in a prime location to serve as a future maglev terminal. Its intermodal transportation capability is well documented, however, run-through flexibility should be improved. This improvement may be possible west of the station by constructing a southbound connection to the existing lakefront trackage which parallels State Highway 5.

Rochester

The existing intercity rail terminal in Rochester is in a fair location and could serve as a future maglev terminal. However, the trackage accessing the terminal from both the east and west has some constraining curvature and should be straightened if at all possible. Additional investigation into alternative terminal locations should occur at some future time.

Syracuse

Officials in Syracuse have recognized the inability of their existing rail terminal to serve as a future intermodal terminal and have initiated studies for a new site. However, there are some reservations about the location of the proposed Park Street site with respect to its proximity to downtown and Syracuse University. The possibility of sharing the Interstate 690 right-of-way north of downtown and reusing the old New York Central terminal should be re-examined.

Albany

It would be possible to have the maglev terminal in Rensselaer, which has adequate bus and taxi connections into the greater Albany area. However, other locations for an intermodal terminal are being discussed and it is too soon to tell if any of these garner support. Another issue which will impact the decision is the proposal to link a future intermodal terminal in Rensselaer with an extensive Riverfront development. For the most part, the corridor running through Albany / Rensselaer is suitable for higher speed operation.

New York City

Penn Station is the intermodal terminal facility in New York City and is undergoing an extensive improvement project. However, there are some problems in using this terminal as a future maglev station. First, the tunnels under the Hudson and East Rivers are very narrow and would not allow wider equipment without modification. Second, Penn Station suffers today from the lack of operational capacity. Lastly, trains accessing Penn Station from the north must travel the Westside Connection which includes a very constrained curvature as it approaches the station. All of these issues must be addressed adequately before Penn Station could be used as a future maglev station. If maglev access into Penn Station is not possible for some reason, an alternative transfer station outside the city would have to be evaluated.

Pittsburgh

Penn Station is centrally located and could serve as a future maglev station. However, the hilly topography of the metropolitan area creates a difficult climate for high speed operation. Curves are tight and grades are steep and maglev (or other high speed technology) would have to overcome these with expensive structures and bridges.

Philadelphia

The 30th Street Station is ideally situated for use as a future maglev terminal. It is truly an intermodal facility and appears to have adequate capacity for additional transportation infrastructure. Obviously, the Northeast Corridor is perhaps the best corridor in the nation for further high speed improvements.

Boston

The intermodality and commercial activity present at the South Station Transportation Center, coupled with on-going improvements on the New Haven to Boston corridor, makes this an ideal location for a future maglev terminal.

Washington, D.C.

The unique mix of transportation modes, commercial activity and the relatively high speed Northeast Corridor makes Union Station the likely candidate for a future maglev terminal in Washington, D.C.

The above discussion on transportation terminals in the 15 selected cities is summarized on the attached Table 7-1, Existing Station Characteristics Matrix.

● - Good
◍ - Fair
○ - Poor

TABLE 7-1

EXISTING STATION CHARACTERISTICS MATRIX

CITIES	Owner of Terminal	Owner of Existing Corridor(s)	Existing Terminal Location	Existing Corridor Access	Multimodal Connections and Interfaces	Connection to Airport	Adequate Parking	Proximity to Travel Attractions, Generators and Transportation Facilities	Additional Transportation Capacity	Overall Feasibility for High Speed Implementation	
SAN FRANCISCO:											
4th and Townsend	Joint Powers Board	Caltrans	◍	●	◍	◍	●	◍	●	◍	
Second St./ Transbay	Joint Powers Board	Caltrans	●	●	●	●	◍	●	●	●	
LOS ANGELES	Catellus	LACTC	●	●	●	◍	●	●	◍	●	
SAN DIEGO	Catellus	ATSF	●	◍	●	●	◍	●	●	●	
ST. LOUIS:											
Union Station	Omni International	TRRA	●	●	●	●	◍	●	●	●	
Trans. Center	City	TRRA	◍	●	◍	●	●	◍	●	●	
CHICAGO	CUS	SPTC/ATSF	●	●	●	◍	◍	●	○	●	
CLEVELAND:											
Lakefront	Amtrak	Conrail	◍	●	◍	◍	○	◍	●	◍	
Tower City	Tower City Development	Conrail	●	◍	●	●	◍	●	●	●	
BUFFALO:											
Depew Station	Amtrak	Conrail	○	●	○	◍	●	○	●	◍	

● - Good
◍ - Fair
○ - Poor

TABLE 7-1

EXISTING STATION CHARACTERISTICS MATRIX

CITIES	Owner of Terminal	Owner of Existing Corridor(s)	Existing Terminal Location	Existing Corridor Access	Multimodal Connections and Interfaces	Connection to Airport	Adequate Parking	Proximity to Travel Attractions, Generators and Transportation Facilities	Additional Transportation Capacity	Overall Feasibility for High Speed Implementation
BUFFALO (Cont'd)										
Exchange St.	Amtrak	Conrail	●	◍	●	◍	◍	●	●	●
ROCHESTER	Amtrak	Conrail	◍	◍	◍	◍	●	◍	●	◍
SYRACUSE:										
East Syracuse	Amtrak	Conrail	○	◍	○	○	●	○	◍	○
Park St. Station	CNY Regional Market	Conrail	◍	◍	◍	●	◍	◍	○	◍
ALBANY:										
Rensselaer	Amtrak	Amtrak/ Conrail	◍	●	◍	◍	◍	◍	●	◍
Everett Rd./I-90	N.A.	Amtrak/ Conrail	◍	●	◍	●	●	◍	●	◍
NEW YORK CITY	Amtrak	Amtrak	●	●	●	◍	○	●	○	●
PITTSBURGH	Amtrak	Conrail/ CSX	●	◍	●	◍	◍	●	●	◍
PHILADELPHIA	Amtrak	Amtrak	●	●	●	●	◍	●	●	●
BOSTON	Beacon Development	MBTA/ Conrail	●	●	●	●	◍	●	◍	●
WASHINGTON, D.C.	Amtrak	Amtrak	●	●	●	●	◍	●	◍	●

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10. Maglev Guideway Route Alignment and Right-of-way Requirements, Final Report, Martin Marietta Corporation, Air Traffic Systems Division, October 1992.

11. Peninsula Commute Service, San Francisco Downtown Station Relocation Study, Draft Environmental Impact Statement / Draft Environmental Impact Report, Parsons Brinckerhoff Quade & Douglas, Inc., et al., August 1991.

12. "San Diego Trolley: 10 years Old and Growing", *Progressive Railroading*, September 1991, pages 91-95.

13. St. Louis Regional Transportation Center, Multi-Modal Station for the Metropolitan Area, Sverdrup Corporation, February 1991.

14. "Metro Link: Simplicity in Design", *Railway Track & Structures*, August 1992, pages 17-18.

15. Rail Access to Cleveland Union Terminal, National Railroad Passenger Corporation, December 9, 1991.

16. Privitization Study for Intermodal Transportation, Task 12, Executive Summary, Final Report, R.L. Banks & Associates, Inc., July 29, 1992.

17. Transportation Center, Feasibility Study for the Park Street Location, Syracuse Metropolitan Transportation Council, January 1991.

18. "Historic Bridge Rehabbed For Rails", *Engineering News-Record,* January 6, 1992, pages 20-21.

19. "Rejuvenated LRT Part of Pittsburgh's Renaissance II", Ken Fisher, *Mass Transit,* July 1983, pages 10-11, 37, 39, 60, 65.

20. Report of the Preliminary Feasibility Study of the Pittsburgh MAGLEV Project, MAGLEV Working Group, February 23, 1990.

21. Proposed Development Program at 30th Street Station, Zuchelli, Hunter & Associates, Inc.

APPENDICES

APPENDIX A

CALCULATIONS FOR

TRUCK TYPE SELECTION

APPENDIX A

TRUCK TYPE SELECTION

Maximum 12°30' curve radius = 459.28'
HSST end car length = 72.18 ft
HSST Mid car length = 65.62 ft.

ARTICULATED TRUCK OPTION:

ASF Articulated connection assembly = 2 x 8" + 2 x 15"
= 46" = 3'10" (from Figure 1 of the ASF Articulated Connection Assembly attachment)

HSST loaded wt.	=	66,000 lbs
Assume flat car wt.	=	60,000 lbs
Total	=	126,000 lbs

Assume wheel base = 5' - 8"

Truck centers (centerline to centerline of ASF connection)
Mid cars = 65.62 + 3.83' = 69.45' say 70'
End cars = 72.18 + 3.83' = 76.01' say 76'

Clearance (Western) diagram width = 10'-0"

Amtrak base car = 60' Truck Centers
86' Overall length

Overhangs for base car

$$\text{Middle OH} = 459.28 - \left(459.28^2 - \frac{60^2}{4}\right)^{1/2} + 5$$
$$= 0.98 + 5$$
$$= 5.98'$$

$$\text{End OH} = \left[(459.28 - 5.98 + 10)^2 + \frac{86^2}{4}\right]^{1/2} - 459.28$$
$$= 6.01'$$

Overhangs for mid car =

$$\text{Middle OH} = 459.28 - \left(459.28^2 - \frac{70^2}{4}\right)^{1/2} + \frac{10.5}{2}$$
$$= 1.34 + 5.25$$
$$= 6.59'$$

APPENDIX A (CONT.)

Excess OH = 6.59' - 5.98' = 0.61'

Reduce car width by 2 x 0.61 = <u>1.22</u> Ft

Req'd width = 10.5 - 1.22
= 9.28 Ft
vs 10.5 Ft (Existing HSST 300 width)

End OH= $[(459.28 - 6.59 + 10.5)^2 + \frac{65.62^2}{4}]^{1/2} - 459.28$

= 5.07 Ft < 6.01 Ft.
O.K.

Overhangs for end car:

Middle OH= $459.28 - (459.28^2 - \frac{76^2}{4})^{1/2} + \frac{10.5}{2}$
= 1.57 + 5.25
= 6.82'

Excess OH = 6.82 - 5.98 = 0.84 Ft

Reduce car width by 2 x 0.84 = 1.68 Ft

Req'd width = 10.5 - 1.68 = 8.82 Ft vs 10.5 Ft (Existing HSST 300 width)

For the articulated truck option to be used with the HSST-300 maglev system, the HSST-300 vehicle width would have to be reduced to 8'-10" to fit within the composite U.S. summary clearance diagram.

STANDARD TRUCK OPTION

* Set truck centers to be at <u>maximum</u> of 60'
* Overall length - any length <u>less</u> than 86 feet

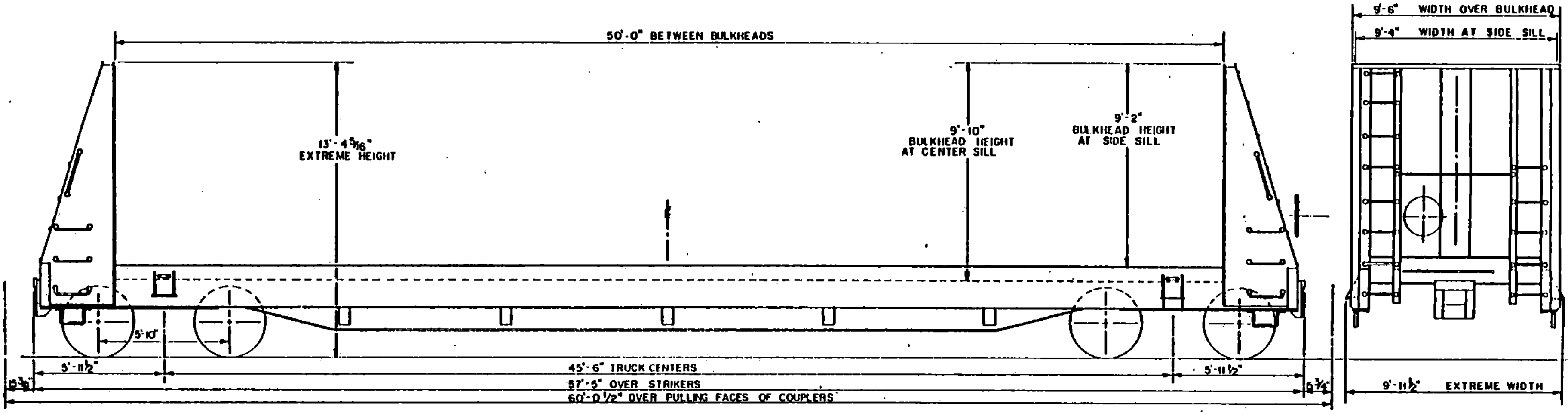
This is possible.

No reduction in the width of the HSST-300 vehicle is required.

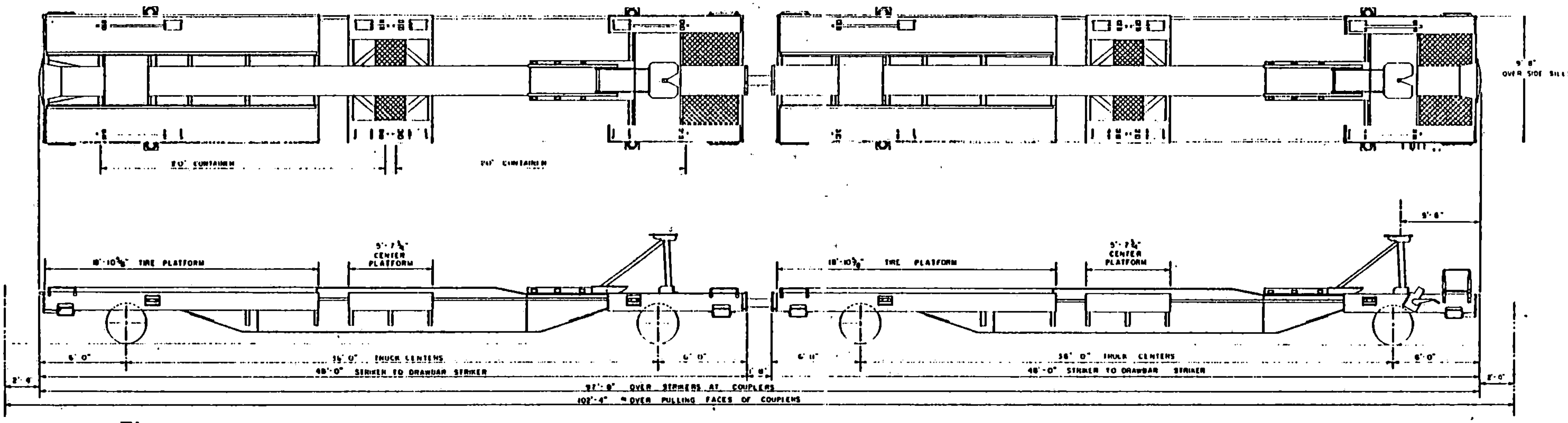
APPENDIX B

SURVEY OF
AVAILABLE RAIL CAR MARKET

Portec Flat Cars



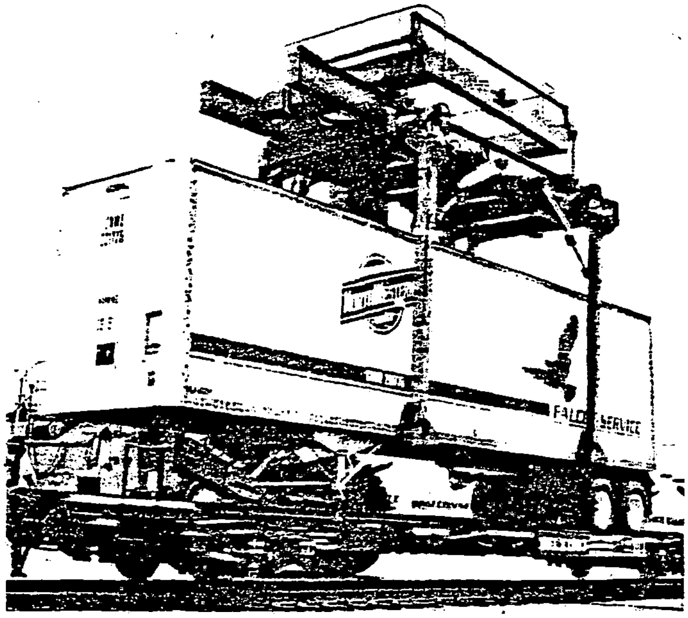
50'0" 100 Ton Bulkhead Flat Car



TRACAR™ Intermodal Flat Car

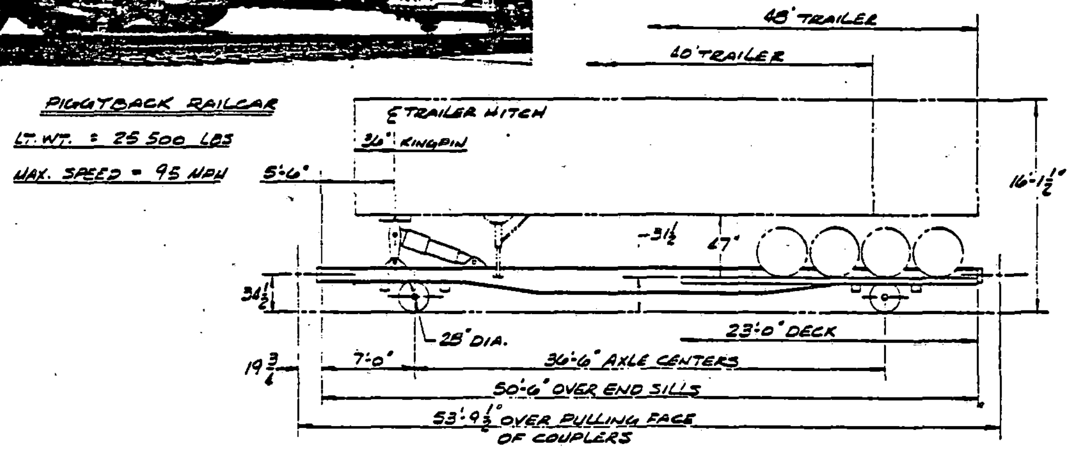
Portec Inc.
Railcar Group
1800 Century Blvd., NE
Atlanta, GA 30345
1-404/329-0400
Telex #810-751-0374

EVANS PROTOTYPE SINGLE AXLE PIGGYBACK FLATCAR



The Evans prototype flatcar is a single axle intermodal piggyback railcar designed to haul trailers from 28' to 48' in length and 102" wide. An extended length version of this car will allow the shipper to have a trailer up to 50' long.

The car is equipped with a clasp brake system and a cushioned trailer hitch, designed and tested to meet AAR Specification M-1001, Chapter VIII and M-928, latest revision.




```
Dimensions  -  50' Trailer Car
Length over strikers-----------638"---(53'2")*
Length over end sills----------630"---(52'6")*
Hitch location from "B" striker-66" --( 5'6")
Length over P.F.C.-------------669½"--(55'9½")*
Axle centers-------------------462"---(38'6")*
Length of overhang (to end sill)84"---( 7'0")
Maximum width (at deck)--------110-5/8"-(9'2-5/8")
Outside width of tire platform-104-1/8"-(8'8-1/8")
Inside width of tire platform--142-3/8"-(11'10-3/8")
Height of tire platform to top
          of rail---------------31½"----(2'7½")
Top of tire platform to top of
          center sill------------9-7/16"
Total height of 13'6" high trailer
          on car----------------16'0"
```

```
Weights
Estimated light weight of railcar:
     For 48' long trailer car--------25,500 lbs.
     For 50' long trailer car--------25,900 lbs.

Maximum trailer weight---------------65,000 lbs.

*For 48' long trailer car reduce
 length dimensions 2'0".
```

AAR CLASS FC
Trailer Train 89′-4″ "piggyback" (TOFC) flatcar (TTX).

TTX 603797

Company Class ASF10
Built: 9/73
ACF Industries (AMCAR)

Principal Dimensions:

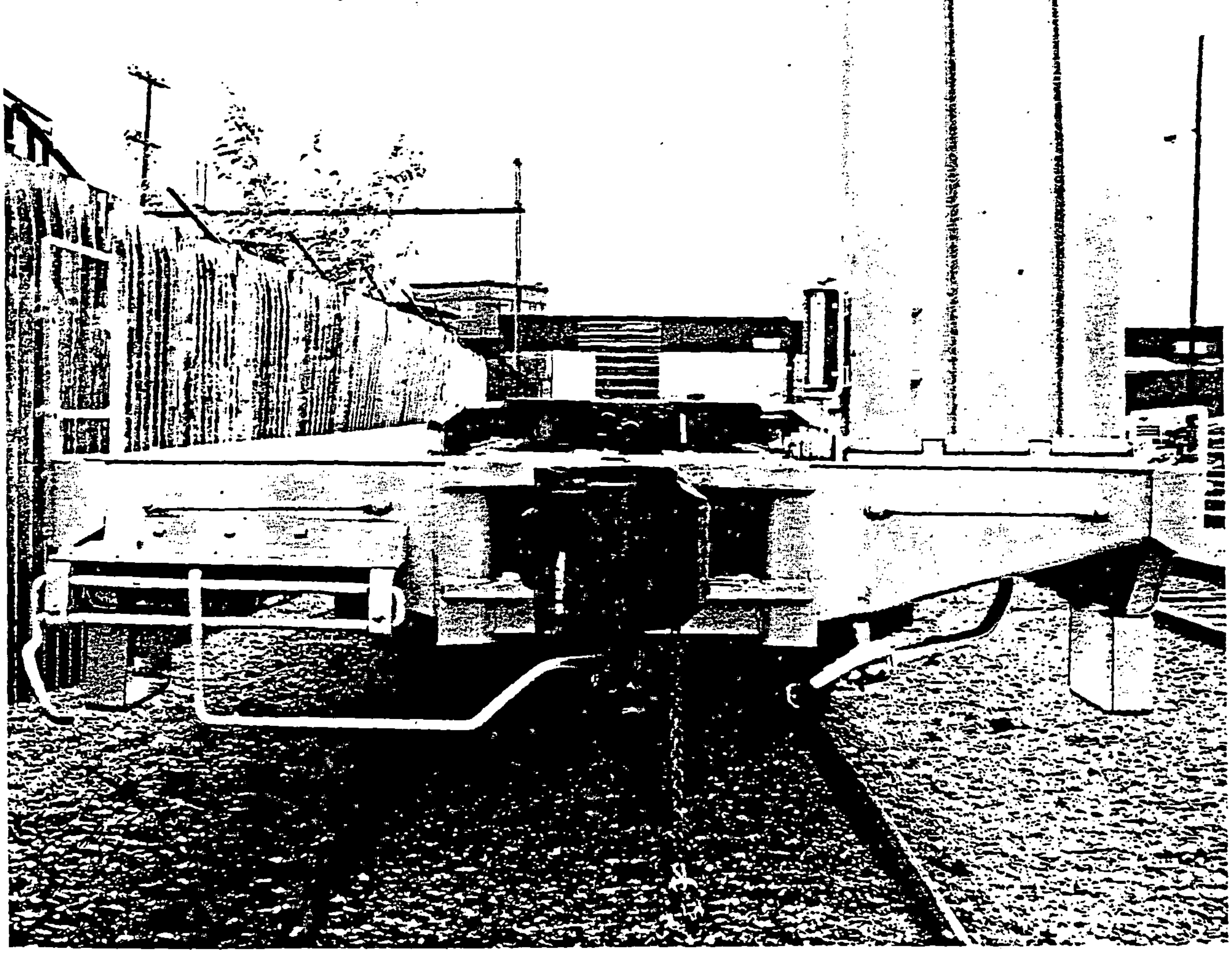
Length (deck):	89′-4″
Length (over pulling faces)	92′-8″
Truck centers:	66′-0″
Width:	9′-0″
Deck height:	3′-6″

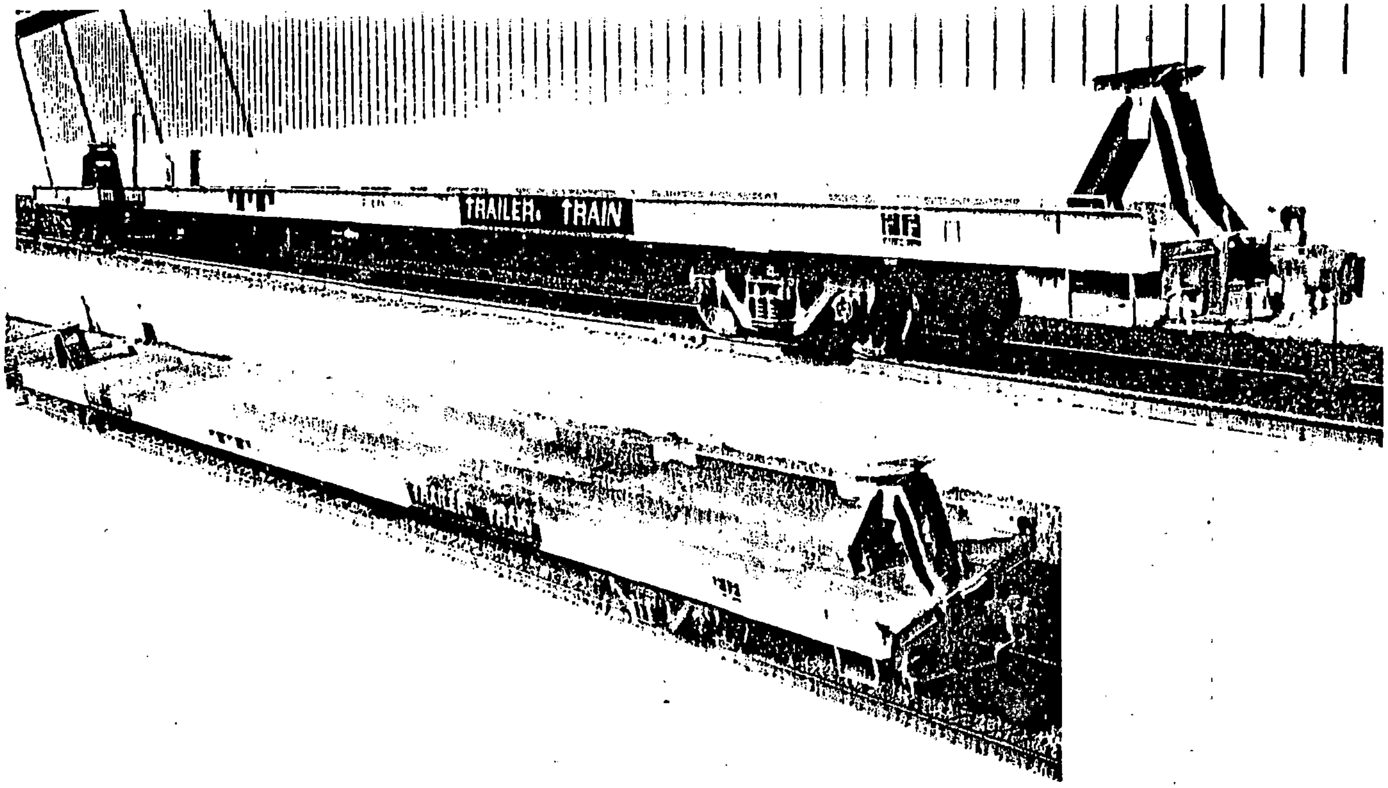
CAPY:	130000 (starred)
LD LMT:	135000 (starred)
LT WT:	68000

Special Features:
Flush (sill below deck) deck design
Two Model 5 cushioned trailer hitche:
48″ bridge plates
Center trailer guide rails
Standard draft gear
Roller bearings, 6 x 11 journals
Will handle one 45-foot and one 40-foot trailer

TRAILER TRAIN
COMPANY

101 NORTH WACKER DRIVE • CHICAGO, ILLINOIS 60606





AAR Class FC
Trailer Train "TWIN 45"
TOFC Piggyback flatcar (KTTX)

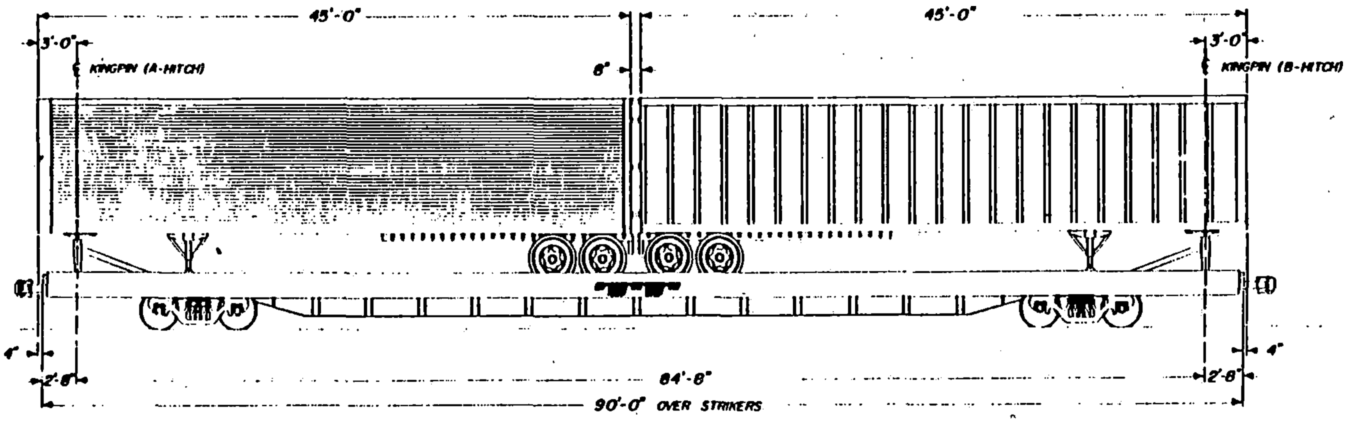
KTTX 912378
Company Class F89 GH
Built: 8-65, ACF
Modified: 4-84, Calpro Division of Trailer Train

Principal Dimensions:

Length (over strikers):	90'-0"
Truck centers:	66'-0"
Width ":	8'-6"
Deck height:	3'-5½"

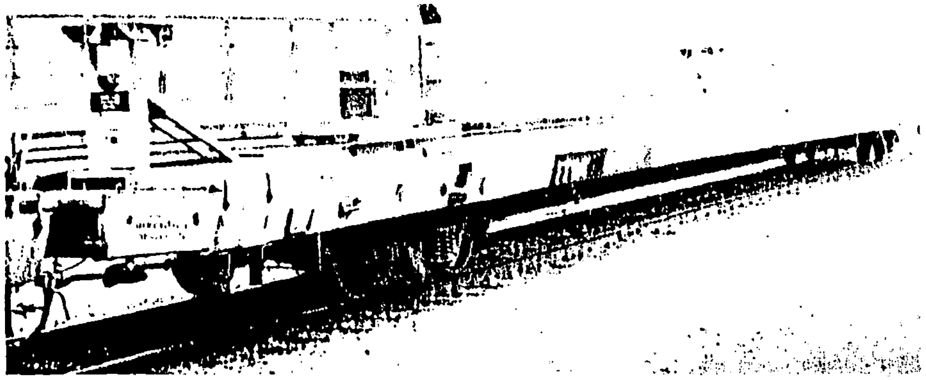
CAPY:	130000 (starred)
LD LMT:	135000 (starred)
LT WT:	71200

Special Features:
Two 45' dry van trailers.
10" end of car hydraulic cushioning
Two non-cushioned, non-retractable hitches.
No bridge plates.
Roller bearings, 6" x 11" journals.
Lift on / lift off loading only.



TWIN 45 **KTTX**

TRAILER TRAIN COMPANY
101 NORTH WACKER DRIVE • CHICAGO, ILLINOIS 60606



AAR Class FC
Trailer Train "TWIN 45"
TOFC / COFC Intermodal flatcar (TTWX)

TTWX 993041
Company Class PSH 10A
Built: 6-80, Pullman Standard
Modified: 11-82, Calpro Division of Trailer Train

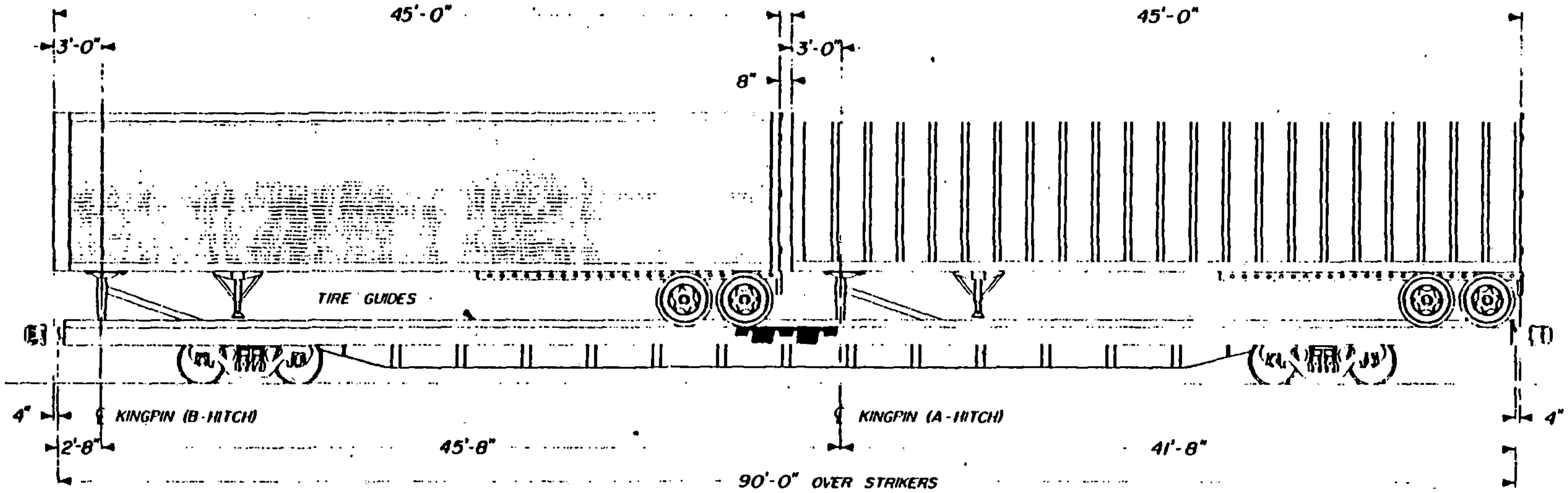
Principal Dimensions:

Length (over strikers):	90'-0"
Truck centers:	66'-0"
Width:	9'-0"
Deck height:	3'-5½"

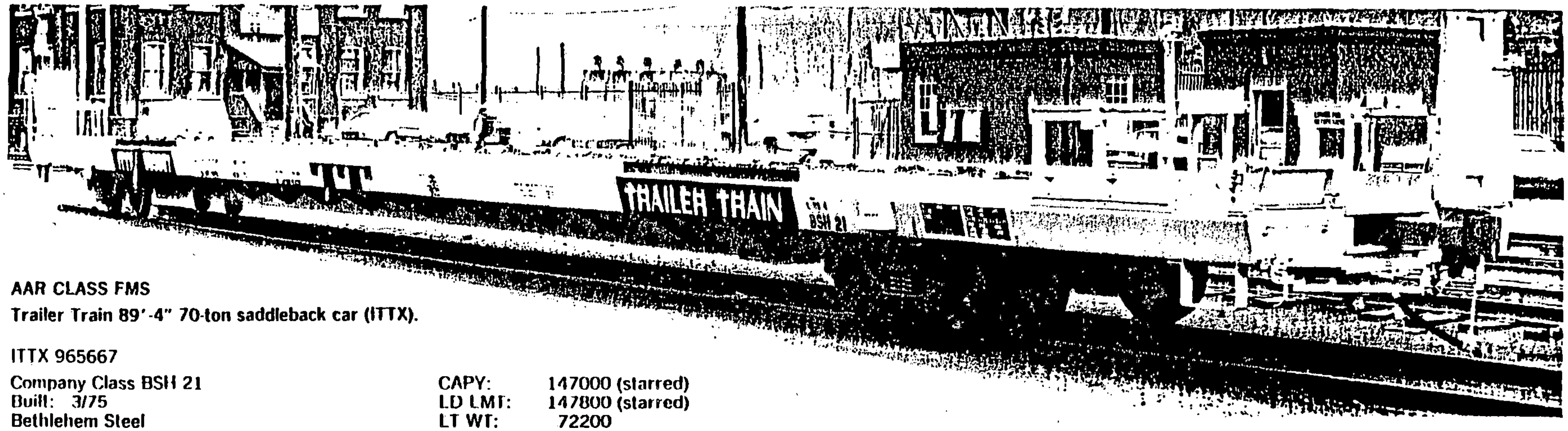
CAPY:	149000 (starred)
LD LMT:	150000 (starred)
LT WT:	68800

Special Features:
Two 45' dry van trailers.
Sixteen retractable and adjustable container pedestals.
Two retractable non-cushioned hitches.
Equipped for use with 60" portable bridgeplates.
15" end of car hydraulic cushioning.
Lift on / lift off loading, or circus loading with portable bridge plates.
Roller bearings, 6" x 11" journals, 33" wheels.

TRAILER TRAIN COMPANY
101 NORTH WACKER DRIVE • CHICAGO, ILLINOIS 60606



TWIN 45 TTWX



AAR CLASS FMS

Trailer Train 89'-4" 70-ton saddleback car (ITTX).

ITTX 965667

Company Class BSH 21
Built: 3/75
Bethlehem Steel

CAPY:	147000 (starred)
LD LMT:	147800 (starred)
LT WT:	72200

Principal Dimensions:

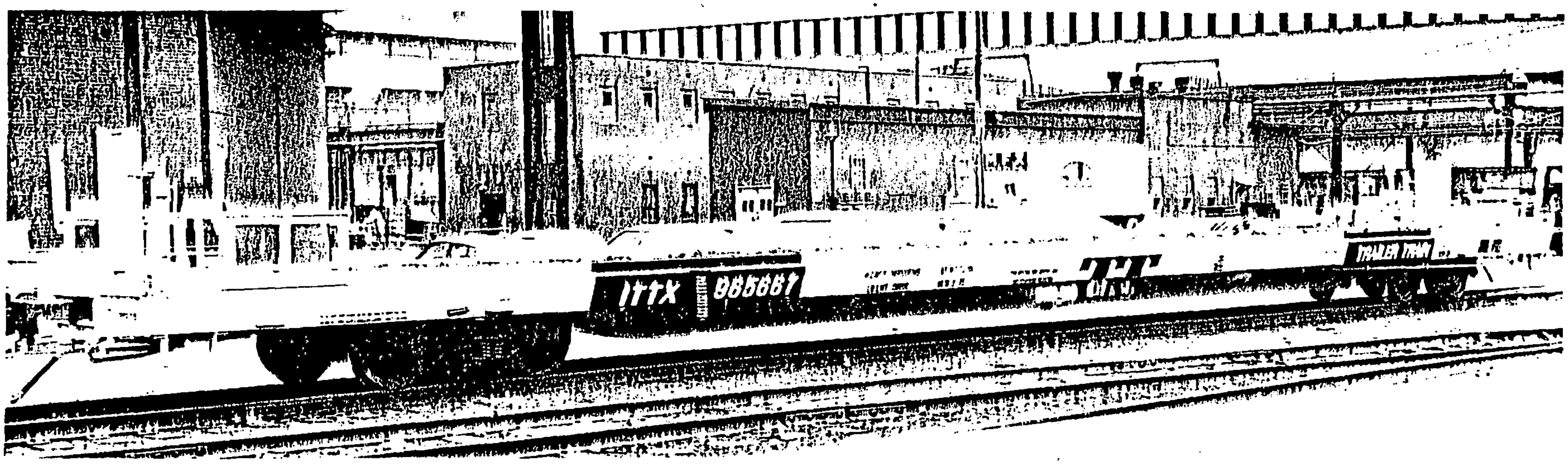
Length (deck):	89'-4"
Length (over pulling faces):	93'-8"
Truck centers:	66'-0"
Width:	9'-0"
Deck height:	3'-6"

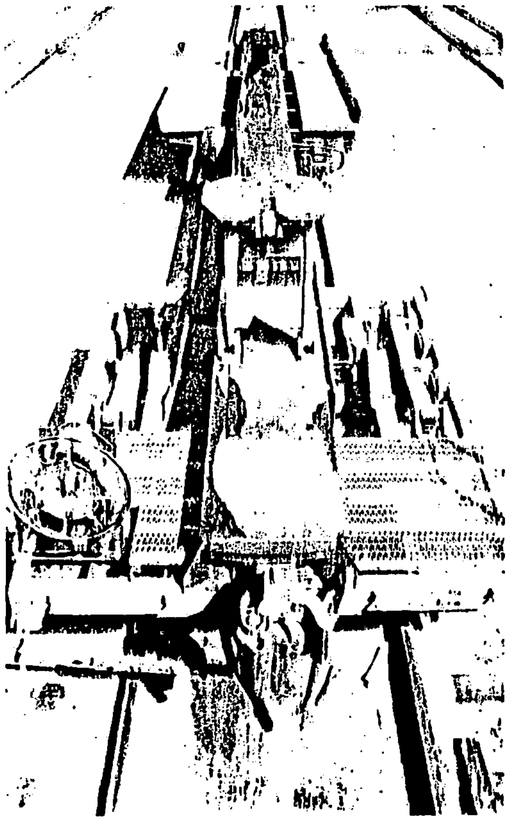
Special Features:

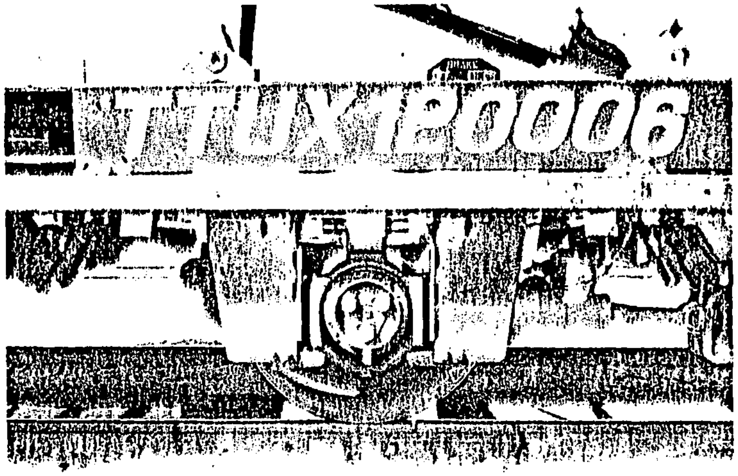
- Dual pedestal system for truck chassis loading
- Bridge plates
- Integral tie-down system
- 10" End-of-car cushioning
- Roller bearings, 6 x 11 journals

TRAILER TRAIN COMPANY

101 NORTH WACKER DRIVE • CHICAGO, ILLINOIS 60606







AAR Class FC
Trailer Train "FRONT RUNNER"
Single Platform Lightweight TOFC Car (TTUX)

TTUX 120006
Company Class: PLF 100
Built: 9-83
Pullman Standard

Principal Dimensions:

Length (over end sills):	50'-6"
Wheel centers:	36'-6"
Width:	9'-1½"
Deck height:	2'-7½"

CAPY:	65000 (starred)
LD LMT:	65000 (starred)
LT WT:	25500

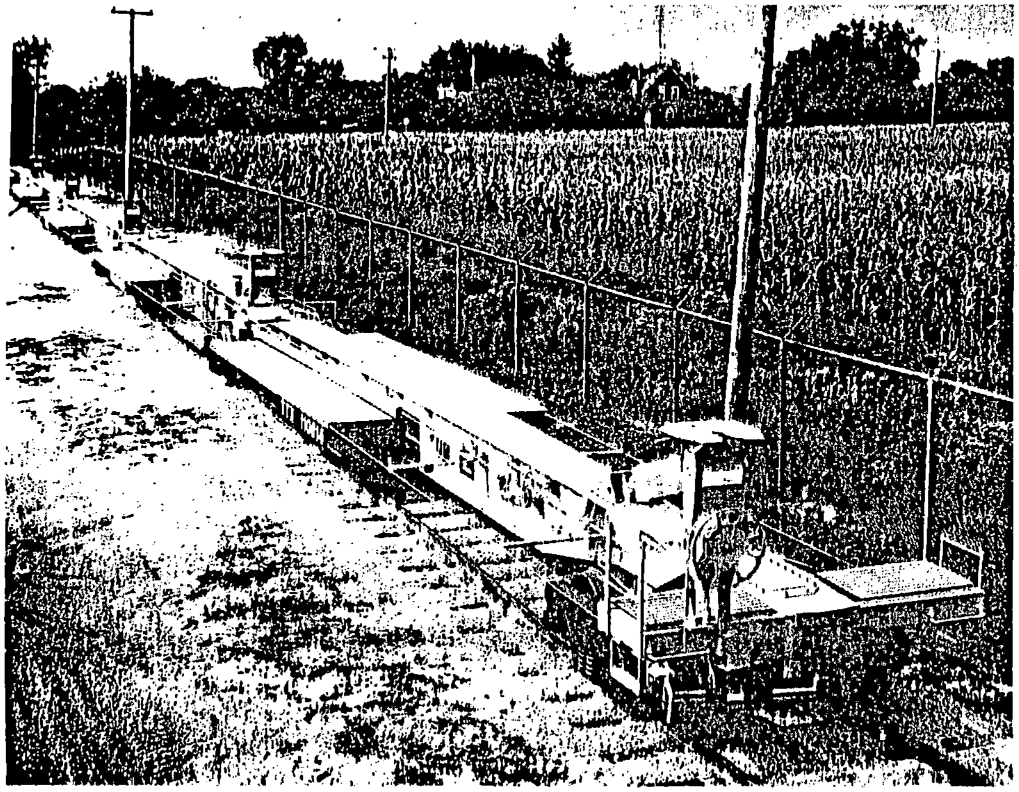
Special Features:
- One trailer from 40' to 48' long at 102" wide
- Trailer can have nose mounted refrigerator units
- Standard draft gear
- Cushioned non-retractable hitch
- Single axle modified U.I.C. trucks
- Roller bearings, 6" x 11" journals, 28" wheels
- No bridge plates
- Lift on / lift off loading only
- Car meets AAR requirements for unrestricted interchange

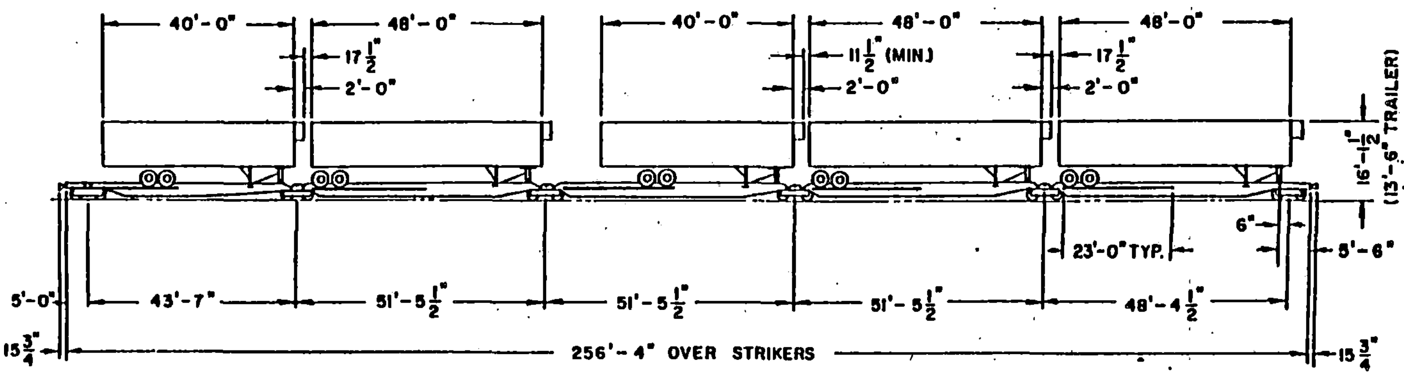
TRAILER TRAIN COMPANY

101 NORTH WACKER DRIVE • CHICAGO, ILLINOIS 60606

TRAILER TRAIN COMPANY

101 NORTH WACKER DRIVE • CHICAGO, ILLINOIS 60606





256'-4" 5 UNIT ARC 5 INTERMODAL CAR

AAR Class FCA
Trailer Train "ARC 5"
Articulated 5 unit TOFC car (UTTX)

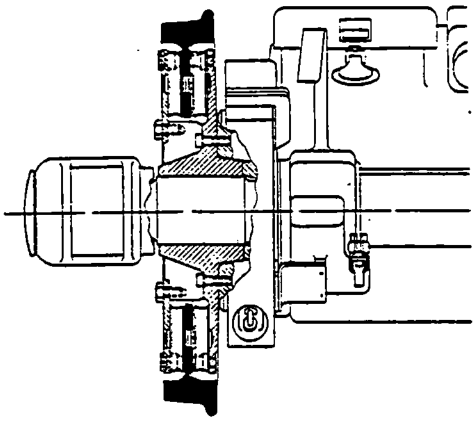
UTTX 110014
Company Class TLF 50
Built: 10-82
Thrall Car Manufacturing Co.
NOTE: UTTX Marks also apply to 5-unit cars designed by Itel and built by FMC Corporation.

Principal Dimensions:

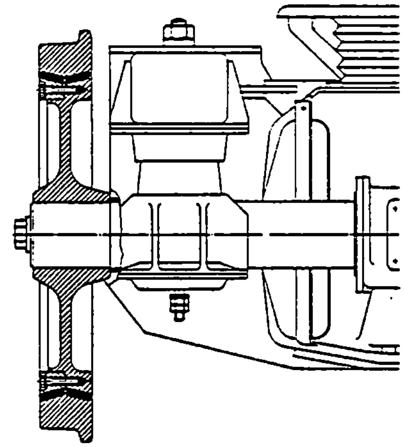
Length (overall):		256'-4"
Truck Centers:	"B" end unit	48'-4½"
	"A" end unit	43'-7"
	Intermediate units	51'-5½"
Width:		9'-0"
Deck Height:		2'-7½"

CAPY:	325000 (5 units) starred
LD LMT:	65000 per unit, starred
LT WT:	121400 (5 units)

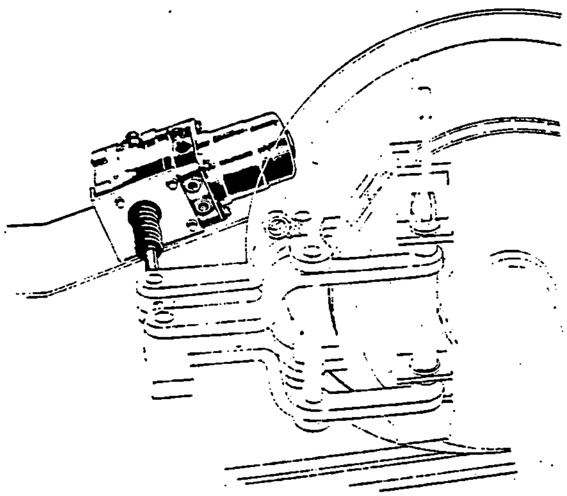
Special Features:
- One trailer per platform from 40' to 48' long at 102" wide
- Trailers can have nose mounted refrigerator units
- Standard Draft Gear
- Cushioned non-retractable hitches
- Standard three piece trucks
- Roller bearings, 6" x 11" journals, 28" wheels
- No bridge plates
- Lift on / lift off loading only
- Car meets requirements for unrestricted interchange



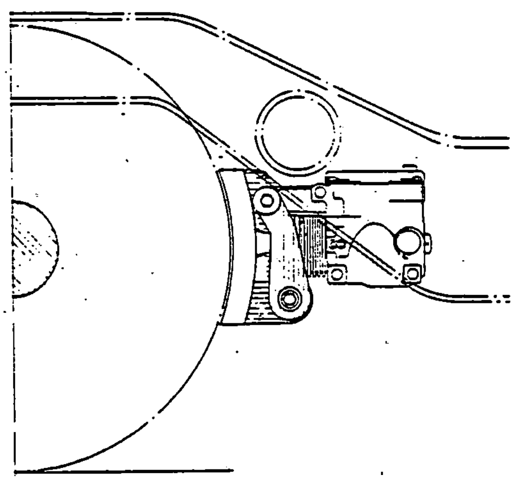
SAB Resilient Wheel



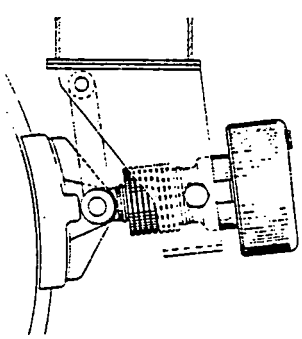
SAB Low-Noise V-Wheel



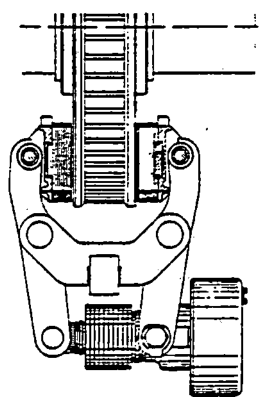
SAB Type BFC-FI
with Disc Brake



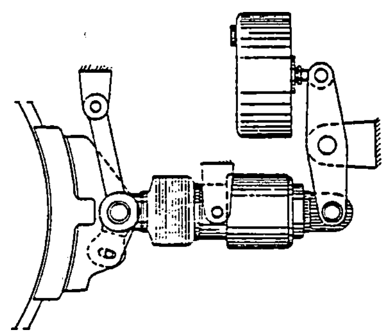
SAB Type BFC
with Tread Brake



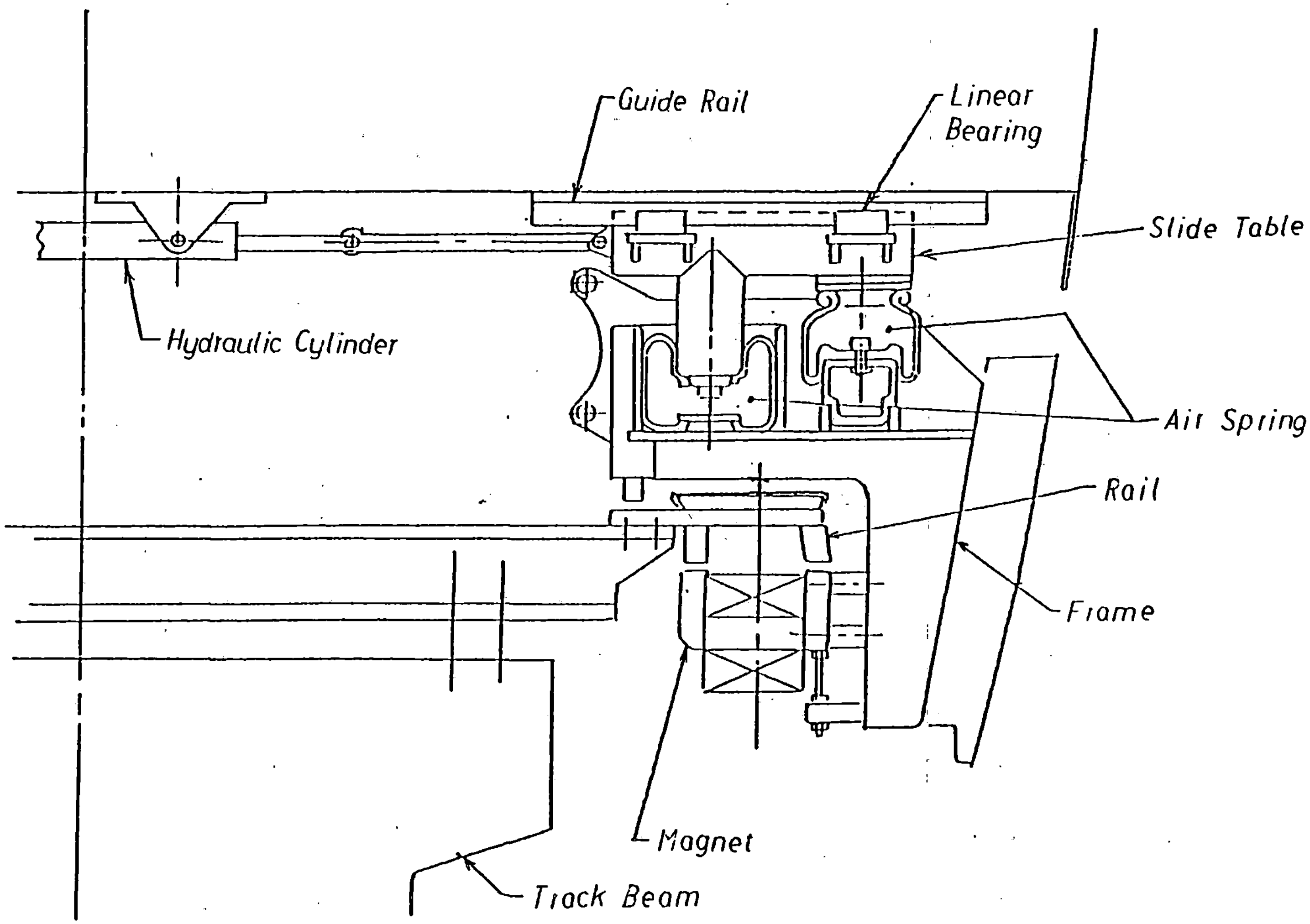
SAB Type PB
with Tread Brake



SAB Type PB
with Disc Brake



SAB Type PBS
with Tread Brake



SECONDARY SUSPENSION

Parsons Brinckerhoff 100 Years

Parsons Brinckerhoff Quade & Douglas, Inc.
Engineers
Planners

3340 Peachtree Road, NE
Suite 2400, Tower Place
Atlanta, Georgia 30326-1001
404-237-2115
Facsimile: 404-237-3015

October 23, 1991

Mr. Hal Gramsey
Thrall Car
2521 State Street
Chicago Heights, Illinois 60411

Re: Maglev Intermodal Rail Carrier

Dear Mr. Gramsey:

This is written with reference to our today's conversation. Parsons Brinckerhoff is under contract with the Federal Railroad Administration to study Maglev/Rail Intermodal Equipment and Suspension. One of the objectives of this study is to verify the preliminary indications suggesting that a rail carrier car can be built which will enable maglev vehicles to utilize existing rail infrastructure to access major inner-city passenger terminals.

Currently we are in the process of evaluating various maglev vehicle designs. Attached is a sketch showing major cross-sectional dimensions of a typical maglev vehicle. In addition:

Length of Vehicle = 50' to 70'
Fully Loaded Weight = Approx. 1,000 lbs./ft.
Guideway Weight = Approx. 400 lbs./ft.

These dimensions and weights are approximate and may be changed to achieve a viable rail carrier and maglev system. Also, all major subsystems such as air conditioning and heating, will be operational while riding the rail carrier.

We would appreciate if you could send us general arrangement drawings and any other pertinent information that we can use in our study. The information you send us will be confidential and will be used only for our study.

Your assistance and thoughts on this subject are most welcome. If you require more information, please call us.

Sincerely,

PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.

Vasant L. Patil, PE
Professional Associate

VLP/dls

Enclosure

Parsons Brinckerhoff 100 YEARS

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Atlanta, Georgia 30326-1001
404-237-2115
Facsimile: 404-237-3015

October 22, 1991

Mr. Gary Baker
Trinity Industries
600 East 9th Street, Suite 5
Michigan City, Indiana 46360

Re: Maglev Intermodal Rail Carrier

Dear Mr. Baker:

This is written with reference to our today's conversation. Parsons Brinckerhoff is under contract with the Federal Railroad Administration to study Maglev/Rail Intermodal Equipment and Suspension. One of the objectives of this study is to verify the preliminary indications suggesting that a rail carrier car can be built which will enable maglev vehicles to utilize existing rail infrastructure to access major inner-city passenger terminals.

I had a chance to briefly discuss this subject with your Mr. Brad Johnstone at the AAR M-1001 Workshop in Champaign. We would appreciate if you could send us general arrangement drawings and any other pertinent information that we can use in our study. The information you send us will be confidential and will be used only for our study.

Currently we are in the process of evaluating various maglev vehicle designs. Attached is a sketch showing major cross-sectional dimensions of a typical maglev vehicle. In addition:

Length of Vehicle = 50' to 70'
Fully Loaded Weight = Approx. 1,000 lbs./ft.
Guideway Weight = Approx. 400 lbs./ft.

These dimensions and weights are approximate and may be changed to achieve a viable rail carrier and maglev system. Also, all major subsystems such as air conditioning and heating, will be operational while riding the rail carrier.

We appreciate your assistance and your thoughts on this subject are most welcome. If you require more information, please call us.

Sincerely,

PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.

Vasant L. Patil, PE
Professional Associate

VLP/dls

Enclosure

Parsons Brinckerhoff 100 YEARS

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Brinckerhoff
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Douglas, Inc.

Engineers
Planners

3340 Peachtree Road, NE
Suite 2400, Tower Place
Atlanta, Georgia 30326-1001
404-237-2115
Facsimile: 404-237-3015

October
~~September~~ 21, 1991

Mr. Tom Engle
New York Air Brake
748 Starbuck Avenue
Watertown, New York 13601

Re: Maglev Intermodal Rail Carrier

Dear Mr. Engle:

This is written with reference to your conversation with our John Reeve. Parsons Brinckerhoff is under contract with the Federal Railroad Administration to study Maglev/Rail Intermodal Equipment and Suspension. One of the objectives of this study is to verify the preliminary indications suggesting that a rail carrier car can be built which will enable maglev vehicles to utilize existing rail infrastructure to access major inner-city passenger terminals.

We have reviewed your brochure on the Iron Highway. The information contained in this brochure is very impressive. We would like to find out more about the Iron Highway to see if it can be a candidate for our study. We would appreciate if you could send us general arrangement drawings and any other pertinent information. The information you send us will be confidential and will be used only for our study.

Currently we are in the process of evaluating various maglev vehicle designs. Attached is a sketch showing major cross-sectional dimensions of a typical maglev vehicle. In addition:

Length of Vehicle = 50' to 70'
Fully Loaded Weight = Approx. 1,000 lbs./ft.
Guideway Weight = Approx. 400 lbs./ft.

These dimensions and weights are approximate and may be changed to achieve a viable rail carrier and maglev system. Also, all major subsystems such as air conditioning and heating, will be operational while riding the rail carrier. Please let us know if you need to know power requirement to operate these subsystems.

We appreciate your assistance. If you require more information, please call us.

Sincerely,

PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.

Vasant L. Patil

Vasant L. Patil, PE
Professional Associate

VLP/dls

Enclosure

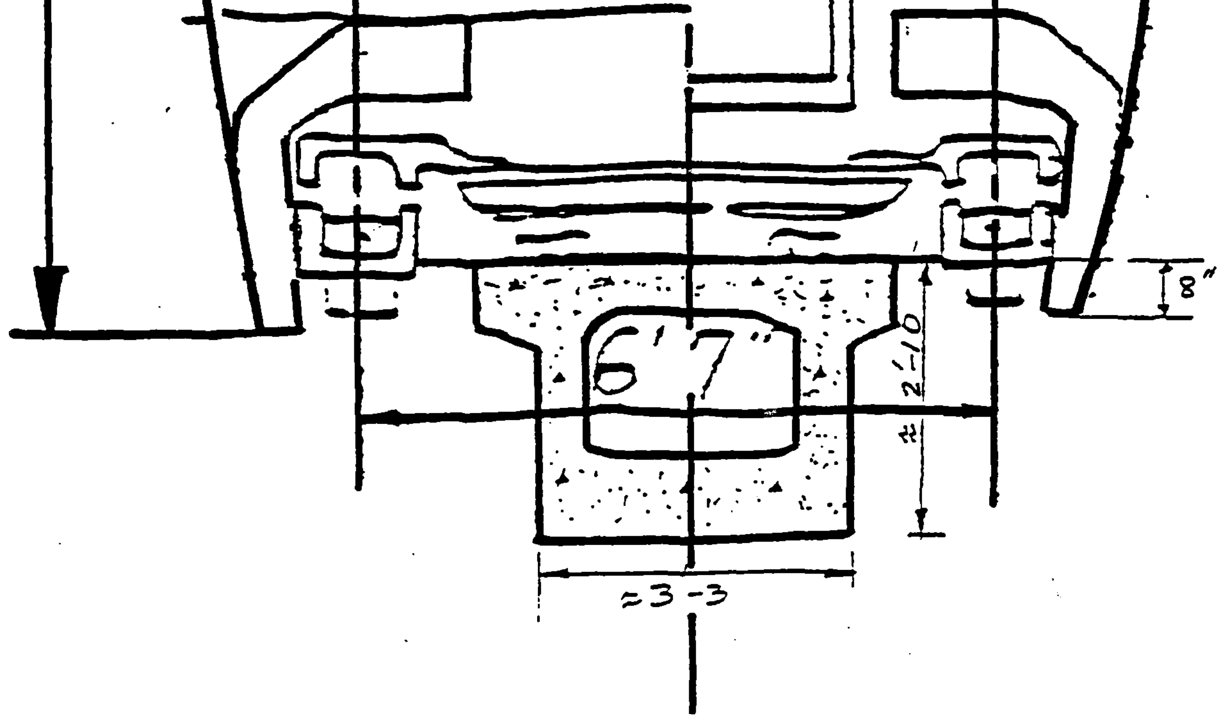
Parsons Brinckerhoff 100 YEARS

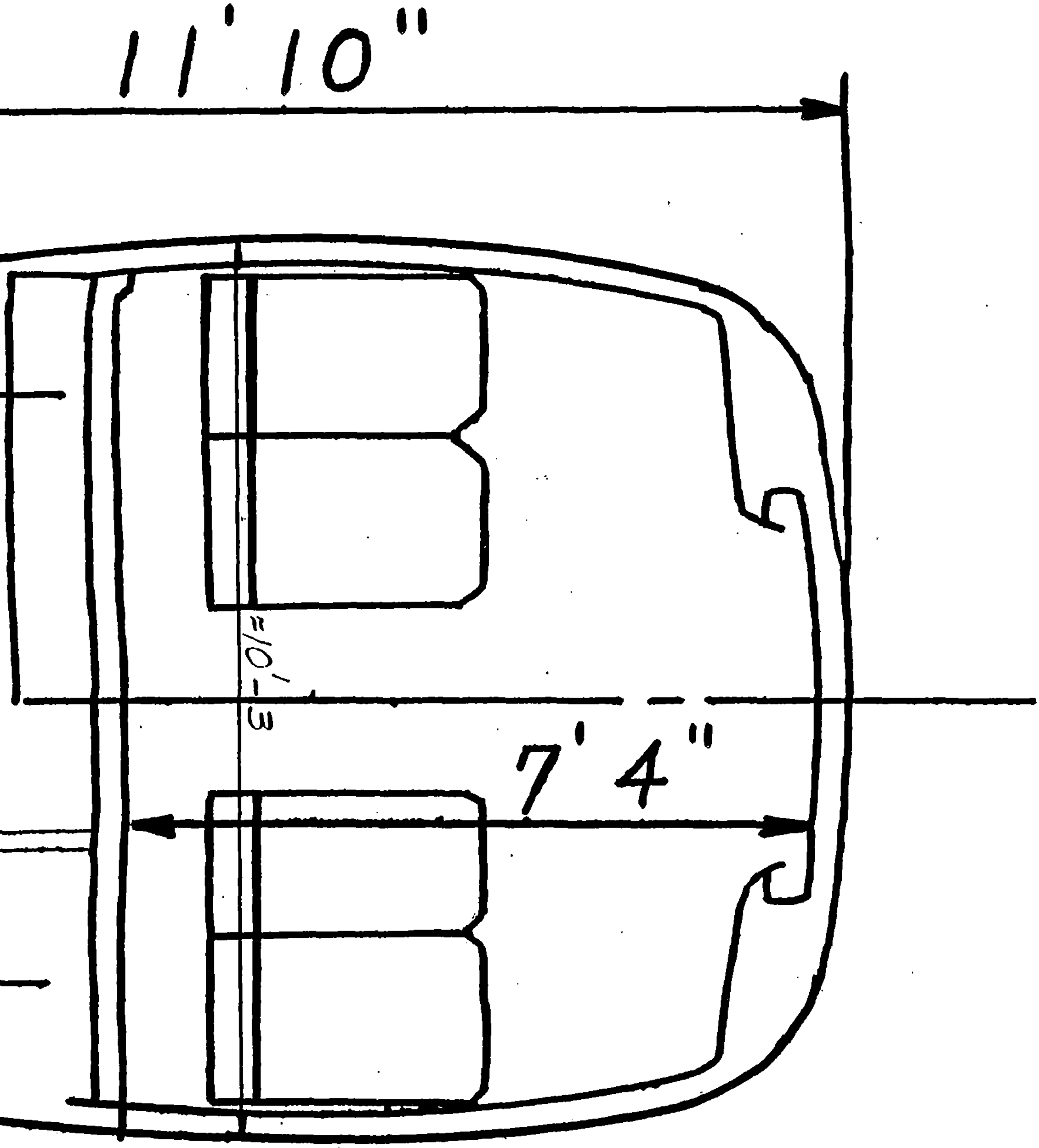
REFERENCE DIMENSIONS

CONTAINER FLAT DECK HEIGHT	2' - 7 1/2"
PLATFORM HEIGHT IN N.Y.C.	4' - 0"
CONTAINER FLAT WHEEL DIA	28"
CLEARANCE LINE	PLATE "B" (UNRESTRICTED)
AVERAGE FLAT CAR CAPACITY	65,000 LBS.
MIN. PANTOGRAPH HEIGHT N.Y.C.	16' - 8"

NOTE:

FLAT CARS ARE EQUIPPED WITH HEAD END POWER JUMPERS TO SUPPLY SERVICES TO "MAGLEV" WHILE IN "PIGGY BACK" MODE. POWER IS SUPPLIED, AND CONSIST MOVED BY STANDARD AMTRAK OVERHEAD ELECTRIC LOCOMOTIVE.


6'7"
≈ 2'-10
8"
≈3-3


11' 10"
7' 4"
10'-3"

GUNDERSON INC.

Gunderson Inc.

4350 Northwest Front Avenue
Portland Oregon 97210
503 228 9281

October 9, 1991

John Reeve
P.B.Q. & D.
Suite 2400, Tower Place
3340 Peach Tree Road, N.E.
Atlanta, GA 30326-1001

Mr. Reeve:

Subject: Information on MAXI-Stack Railcars

Reference our telephone conversation on 10-9-91 regarding the Mag-Lev trains and transporting the car bodies on flat cars, I've enclosed show brochures on the MAXI-I and MAXI-III cars and a general arrangement drawing of the MAXI-III type car. I hope this information is of use to you. Please call if we can be of further assistance.

Sincerely,

Gary S. Kaleta

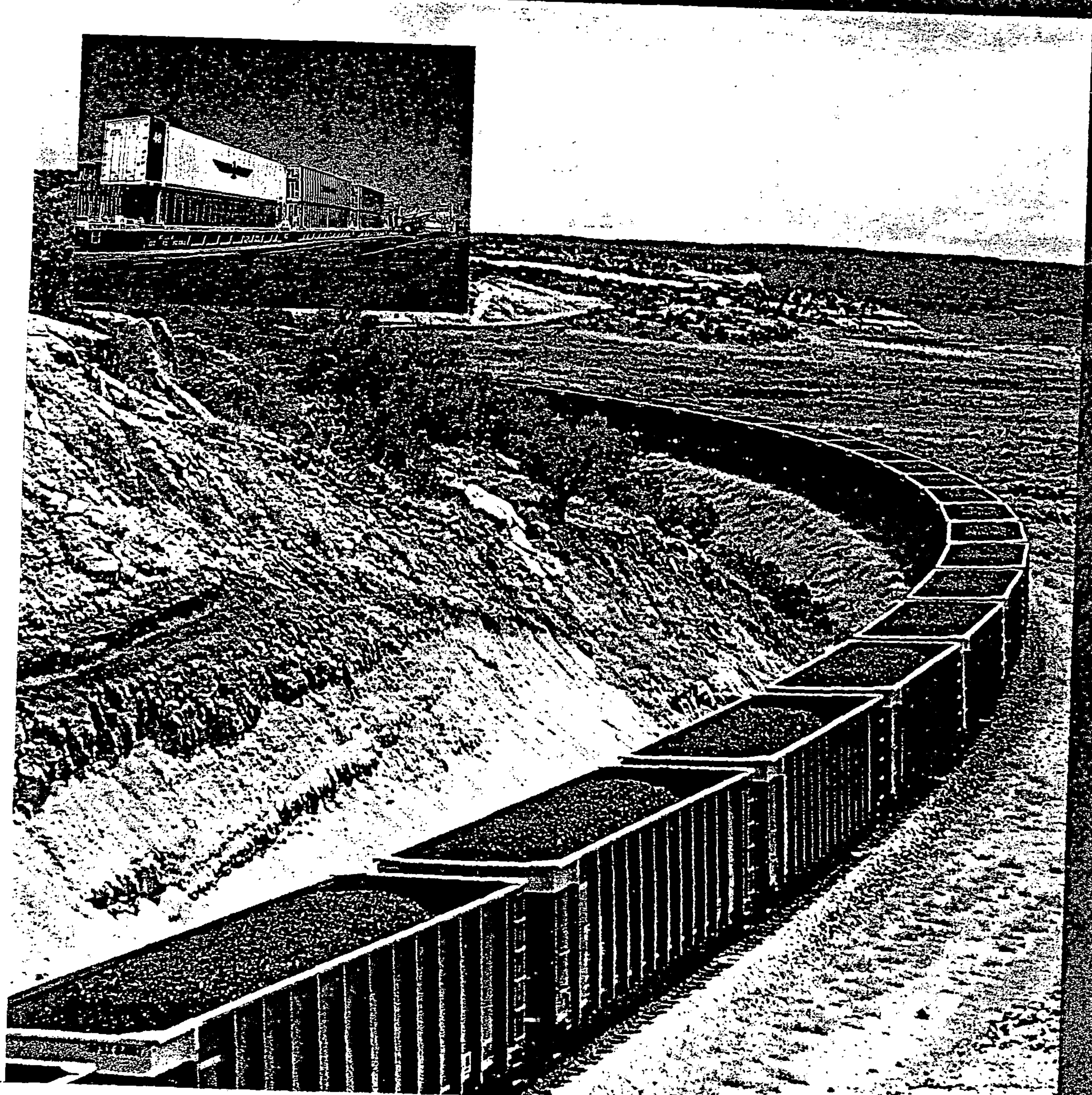
Gary S. Kaleta
Vice President
Railcar Engineering

gk/js
Enclosures (3)

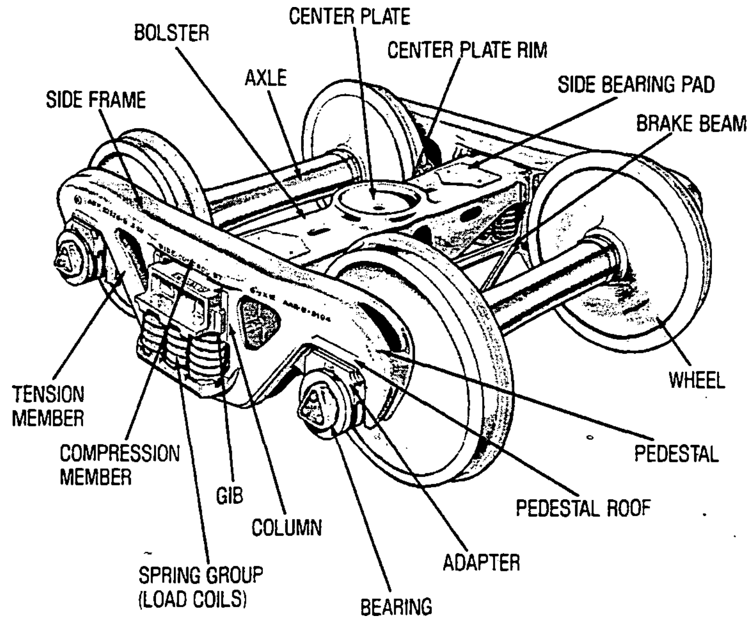
USER'S GUIDE

ASF

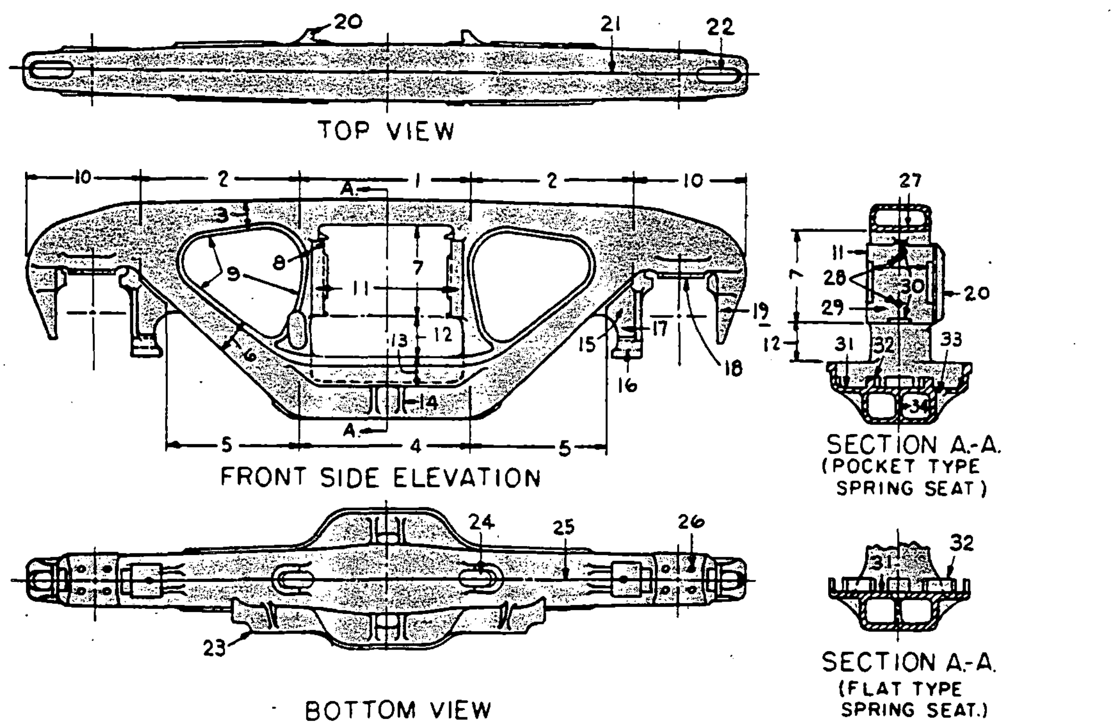
Freight Car Truck Design



THREE PIECE FREIGHT CAR TRUCK



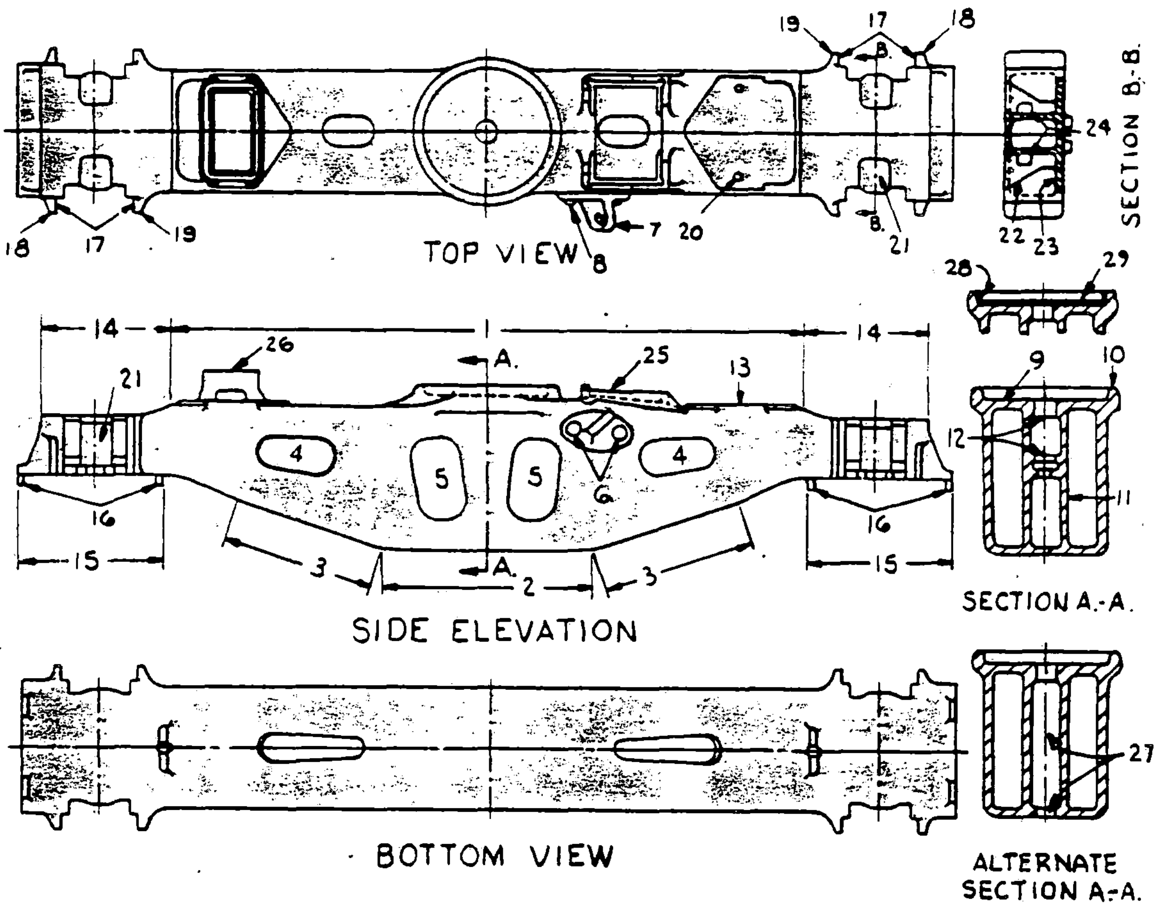
SIDE FRAME NOMENCLATURE



1. TOP MEMBER CENTER
2. COMPRESSION MEMBERS
3. COMPRESSION MEMBER FLANGES
4. BOTTOM CENTER
5. DIAGONAL TENSION
6. TENSION MEMBER FLANGES
7. COLUMNS
8. COLUMN FLANGES
9. WINDOWS
10. TOP ENDS
11. SIDES OF COLUMN
12. LOWER BOLSTER OPENING
13. SPRING SEAT FLANGES
14. SPRING SEAT RIBS
15. JOURNAL BRACKET FLANGES
16. RETAINER KEY SLOT
17. INNER PEDESTAL LEGS
18. PEDESTAL ROOF WEAR LINER
19. OUTER PEDESTAL LEGS
20. BOLSTER ANTI-ROTATION LUGS
21. PARTING LINE-TOP MEMBER
22. TOP END OPENINGS
23. UNIT BRACKETS
24. BOTTOM CENTER DRAIN HOLES
25. PARTING LINE-BOTTOM MEMBER
26. PEDESTAL ROOF WEAR LINER BOSSES
27. TOP MEMBER BRIDGE
28. WEAR PLATE RETAINER HOLES
29. COLUMN FACE
30. COLUMN WEAR PLATE RETAINER BEADS
31. SPRING SEAT
32. SPRING SEAT BOSSES OR LUGS
33. SPRING SEAT DRAIN HOLES
34. BOTTOM CENTER RIB

Double stack container train photo courtesy of Thrall Car Mfg. Co.

BOLSTER NOMENCLATURE

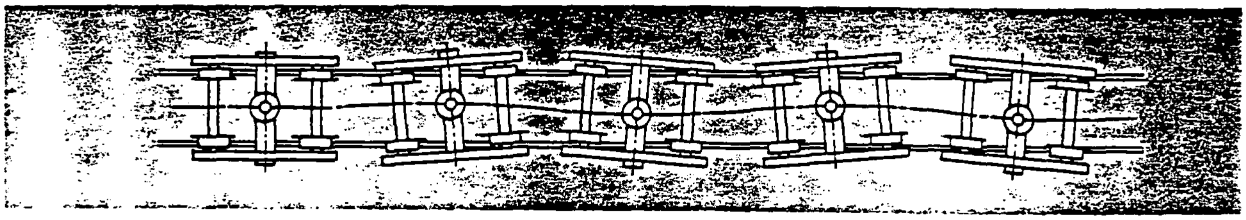


1. TOP OR COMPRESSION MEMBER
2. BOTTOM CENTER MEMBER
3. DIAGONAL TENSION MEMBER
4. SIDEWALL LIGHTENER HOLES
5. BRAKE ROD HOLES
6. DEAD LEVER LUG RETAINER HOLES
7. DEAD LEVER LUG
8. DEAD LEVER LUG RIVETS OR BOLTS
9. CENTER PLATE BEARING SURFACE
10. CENTER PLATE RIM
11. CENTER POST
12. KING PIN WELL
13. SIDE BEARING PADS
14. ENDS
15. SPRING SEATS
16. SPRING SEAT LUGS
17. COLUMNS
18. OUTER COLUMN GUIDES–GIBS
19. INNER COLUMN GUIDES–GIBS
20. SIDE BEARING RIVET OR BOLT HOLES
21. FRICTION SHOE POCKETS
22. FRICTION SHOE BEARING SURFACES
23. RIDE CONTROL SPRING SEATS
24. FRICTION SHOE RETAINING PIN OPENINGS
25. C-PEP POCKET
26. SIDE BEARING POCKET
27. LOCKING CENTER PIN OPENING
28. CENTER PLATE VERTICAL RING WEAR LINER
29. CENTER PLATE HORIZONTAL WEAR LINER

TRUCK HUNTING–ROCK AND ROLL

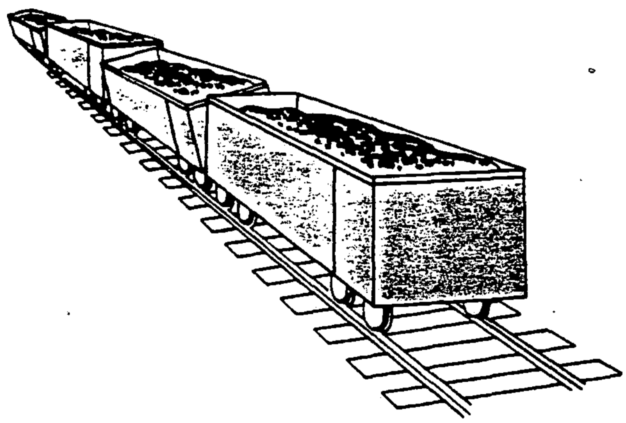
TRUCK HUNTING

An instability at high speed of a wheel set (truck), causing it to weave down the track, usually with the flanges striking the rail. Generally, constant contact side bearings are used to control conventional truck hunting for high speed applications.



ROCK AND ROLL

Excessive lateral rocking of cars, usually associated with low speeds and jointed rail. Such factors as wheel base, center of gravity and spring dampening determine degree of rock and roll



RULE 88 and SPECIFICATION M-965

Cars with four (4) wheel trucks having 6½" x12" journals or larger, having truck centers within the range of 28 feet to 48 feet and loaded center of gravity exceeding 90" above top of rail, to be equipped with 3¹¹⁄₁₆" minimum travel springs and approved supplemental snubbing device or devices in each spring group. Other devices to control car stability in lieu of the above will be acceptable, providing they demonstrate control of car stability through actual test of a prototype car, both loaded and empty, on a test track arranged in accordance with instructions of the AAR Research Department. RIDEMASTER®/ROADMASTER® trucks currently meet the requirements of specification M-965, i.e., they do not require auxiliary snubbing devices.

TRUCK VARIABLES

1. **TYPE TRUCK**
   RIDE CONTROL®, SUPER SERVICE™ RIDE CONTROL®, ROADMASTER®, RIDEMASTER®, BARBER® (S-2), BARBER® HEAVY DUTY (S-2-HD®).
2. **SPRING TRAVEL**
   D5–3¹¹⁄₁₆"
   D7–4¼"[1]
3. **SPRING GROUPS**
   Various–See individual truck capacity charts for standards
4. **TRUCK CASTING GRADE OF STEEL**
   Side frames and bolsters are either grade "B" or "C"
5. **CENTER PLATE DIMENSIONS**

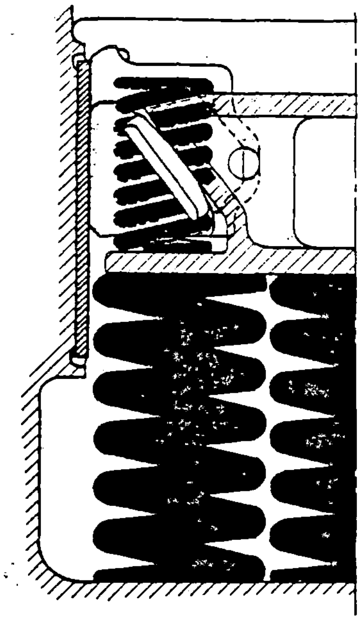
	DIAMETER	RIM HEIGHT	HEIGHT FROM CENTER PLATE TO RAIL
AAR Alternate Standard	14"	1⅛"	25¹⁄₁₆"
AAR Standard	14"	1⅛"	25½"
AAR Alternate Standard	16"	1⅛"	25¹⁄₁₆"
AAR Standard	16"	1¾"	25¹⁄₁₆"
B-N Standard	16"	2"	25¹⁄₁₆"

6. **BRAKE RIGGING**
   Rod Through, Rod Under, Hook And Eye, Wabcopac, Ellcon National[2], Davis Truck Pac[2], NYCOPAC, NYCOPAC II
7. **SIDE BEARING**
   Stucki® Single Roller, Stucki® Double Roller, Stucki® Constant Contact, ASF SIMPLEX®, ASF RIDE CONTROL®, Miner® TecsPak® Constant Contact, Pocket, Monocast.
8. **SNUBBERS**
   Stucki®: HS-7, HS-7-100, HS-10
9. **SIDE FRAME COLUMN FRICTION WEAR PLATE APPLICATION**
   ¾" High Strength Fastener and Two Point Weld
   ¾" High Strength Fastener
10. **PEDESTAL ROOF**
    As cast, Welded, Transdyne, ROADMASTER®
11. **BOLSTER FRICTION SHOE POCKETS**
    As cast, Welded wear plate
12. **CENTER PLATE LINERS–VERTICAL AND HORIZONTAL**
    Manganese, Stainless, Hollube®, etc.
13. **HORIZONTAL AND/OR DEAD LEVER LUG ON BOLSTER**
    Apply or omit.
14. **SIDE FRAME HEIGHT**
    Standard or Low Profile[3]
15. **SPECIAL FEATURES**
    C-Pep
    Elastomeric friction shoes
    Lubrication of friction shoe pockets for new trucks only

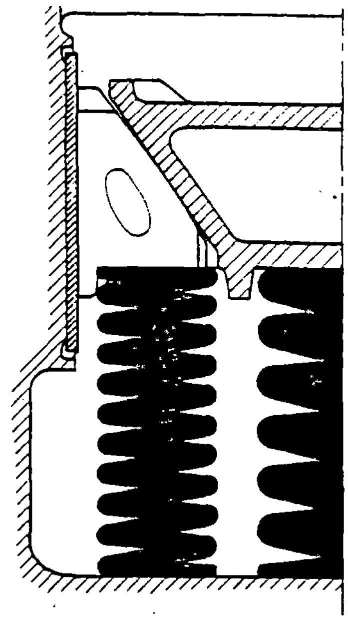
[1] D7–in RIDE CONTROL®, SUPER SERVICE™ RIDE CONTROL®, RIDEMASTER®, ROADMASTER®
[2] These brake systems may require horizontal lugs and/or special mounting pads
[3] Low Profile in D5 Coils only

TRUCK SNUBBING–CONTROL

CONSTANT: AS TYPIFIED BY
RIDE CONTROL®
SUPER SERVICE™ RIDE CONTROL®

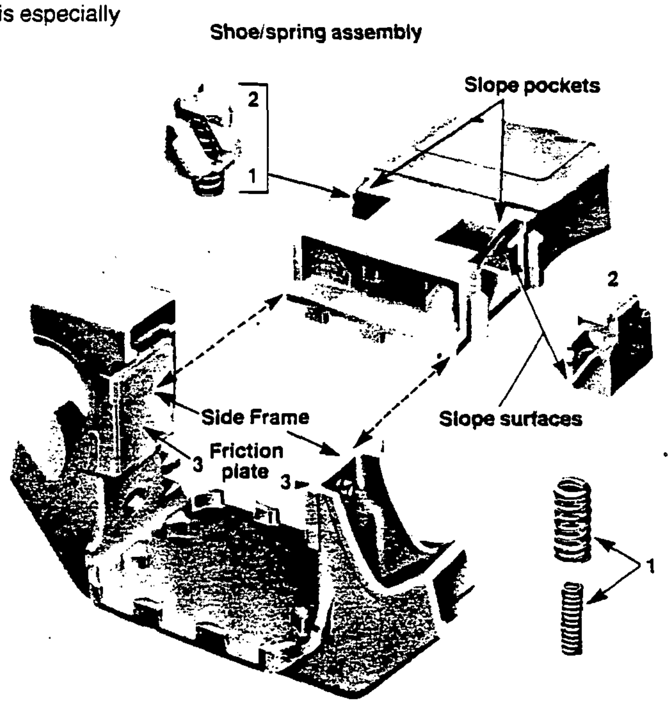


VARIABLE: AS TYPIFIED BY
RIDEMASTER®
BARBER® (S-2)
BARBER® HEAVY DUTY (S-2-HD®)



RIDE CONTROL PARTS

The illustration below points out the side frame and bolster areas where dimensional casting tolerance is especially critical for good truck performance.



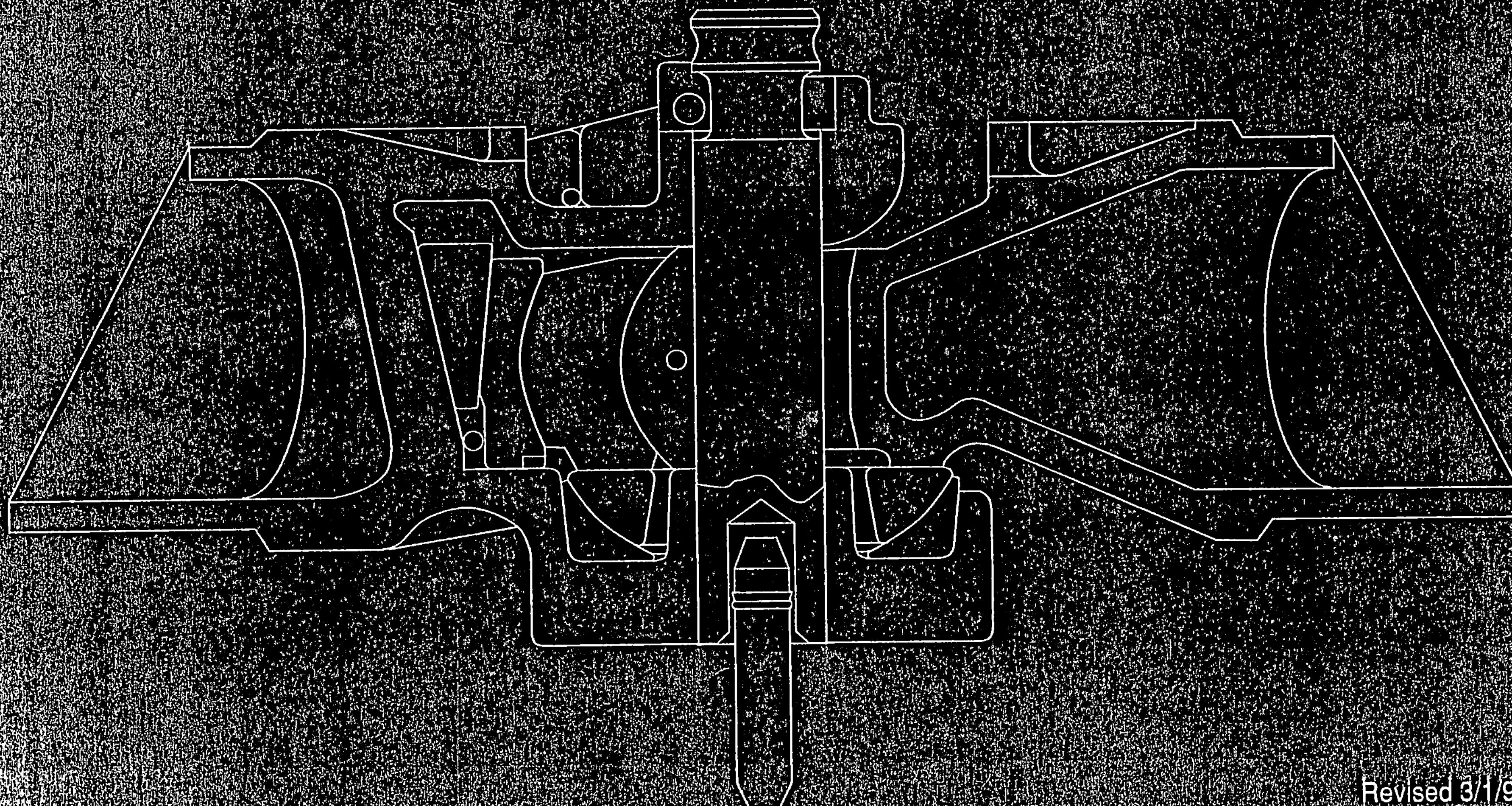
1. Ride Control springs
2. Ride Control friction shoes
3. Ride Control column friction plates

American Steel Foundries

10 S. Riverside Plaza, Chicago, IL 60606 • (312) 258-8000 • (800) 621-8442

Articulated Connection Assembly

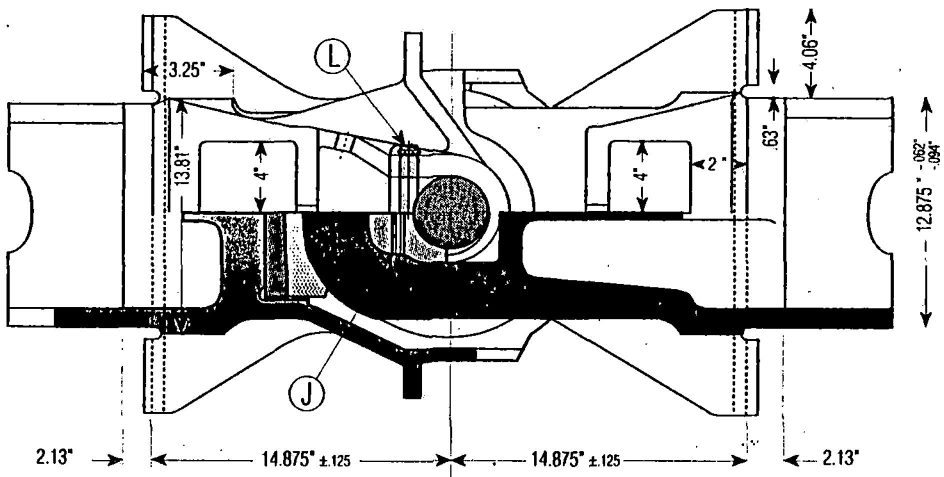
Includes Assembly & Disassembly Instructions



Revised 3/1/92

American Steel Foundries – Articulated Connection Assembly Page 2

A **Male Articulated Connector**
B **Female Articulated Connector**
C **Follower Block**
D **Spherical Ring**
E **Pin Bearing Block**
F **Primary Pin**
G **Wedge Shim**
H **Special Center Pin**
J **Pin Bearing Block Spring ***
K **Retaining Pin**
L **Cotter-$^{5}/_{16}$" x 1 $^{3}/_{4}$" (2 required)**
M **Ring Seat**
N **O-Ring (120 R1-I -325)**



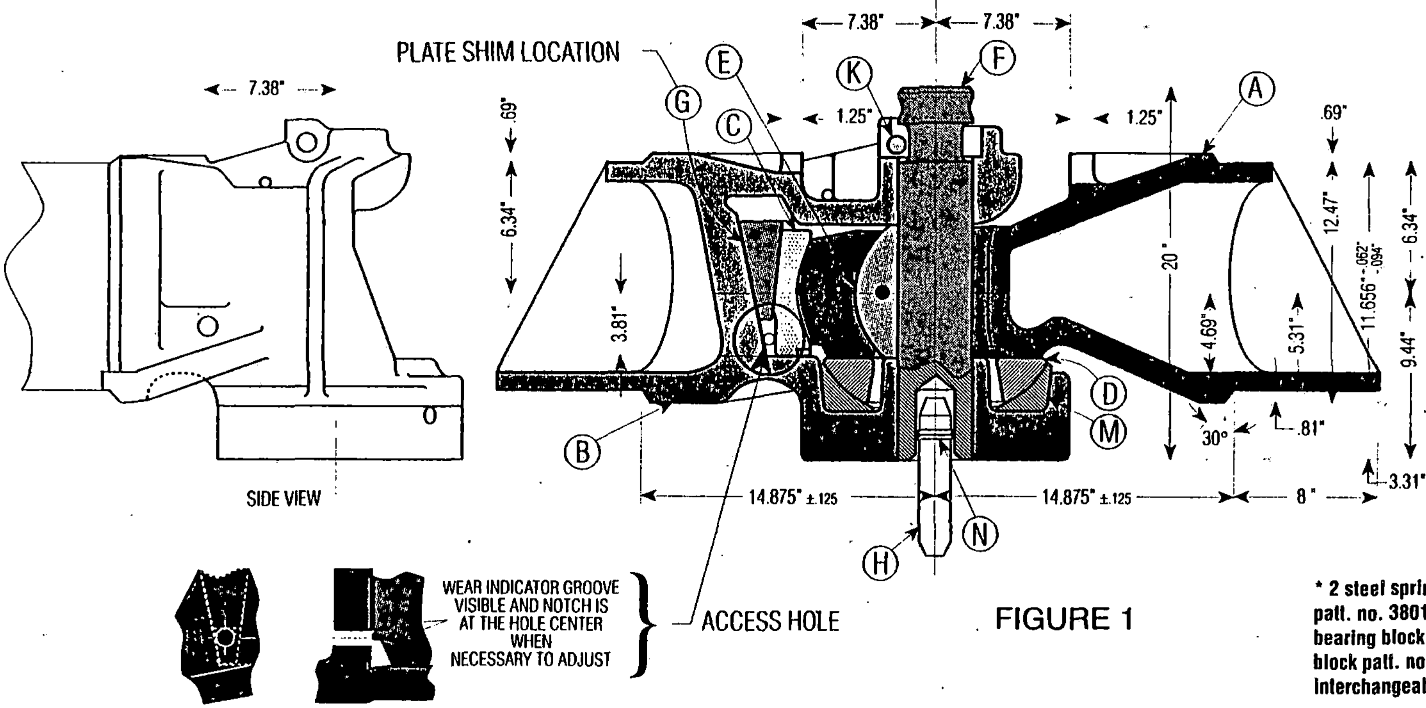


FIGURE 1

The ASF articulated connection assembly is a system that contains a wedge that provides for initial assembly clearance and drops by gravity to maintain zero longitudinal slack. Automatic adjustment for seating and any wear that accumulates is provided by wedge (G) to maintain a slack-free connection. After longitudinal wear, wedge travel is restored by adding a plate shim. Wedge travel is visible through access holes which also permit insertion of a pry bar to raise wedge for ease of assembly and disassembly.

*** 2 steel springs are required for pin bearing block, patt. no. 3801AC. 1 rubber spring is required for pin bearing block, patt. no. 3801B. Both pin bearing block patt. no. 3801AC and 3801B are interchangeable.**

APPENDIX C

CALCULATIONS ON THE POWER REQUIREMENTS FOR THE ROLLER MECHANISM

POWER REQUIREMENTS

FOR ROLLER MECHANISM

HSST loaded wt. = 66,000 lbs
Roller spacing 3'

$$\frac{76'\text{-}4''}{3} = 24 \text{ spaces}$$

Assume 4 rollers per axle - 2 at each end
Rollers = 12" dia. 865 lbs load capacity 155/80/12, 32 PSI Air pressure (source - NTW)
Static vertical load per axle:
axles = 25

$$\frac{66{,}000}{25} = 2640 \text{ lbs/axle}$$

Static load per roller = $\frac{2640}{4}$ = 660 lbs. < 865 lbs. OK

Assume friction coefficient = 0.35 (rough surface to rubber tire friction)

Assume that only half of the axles are powered.
Static vertical load per powered axle = 2 x 2640 = 5280 lbs.

Friction load = 0.35 x 5280 = 1848 lbs./powered axle
torque = 1848 x $\frac{6}{12}$ = 924 ft. lbs.

$$HP = \frac{T \times RPM \times 12}{63{,}025}$$ T in Ft. lbs.

Loading/unloading speed = 4 mph = 352 ft/min
Circumference of 12" wheel = 3.14 ft

$$RPM = \frac{352}{3.14} = 112$$

$$HP = \frac{924 \times 112 \times 12}{63{,}025} = 19.7 \text{ HP}$$

One HP = 746 watts

12 powered axles per car x 10 cars/train	=	120	powered axles per train
	+	120	powered axles on concrete guideway
Total		240	powered axles

$\frac{1725}{112}$ RPM of Motor = 15.4 say 15:1 Ratio Gear Reduction Req'd

$$HP = \frac{19.7}{15} = 1.31 \text{ HP say 1.5 HP Motor}$$

$$1.5 \times 240 = 360 \text{ HP}$$

$$KW = \frac{360 \times 746}{1000} = 268.5 \text{ say } 270 \text{ KW}$$

270 KW REQ'D TO POWER ROLLER MECHANISM

APPENDIX D

BATTELLE PASSIVE SUSPENSION DESIGN REPORT

Battelle
... Putting Technology To Work
505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Facsimile (614) 424-5263

July 6, 1992

Mr. Edward E. Gilcrease, Jr.
Parsons Brinckerhoff Quade & Douglas, Inc.
3340 Peachtree Road NE
Suite 2400, Tower Place
Atlanta, GA 30326-1001

Dear Mr. Gilcrease:

Re: MAGLEV-RAIL INTERMODAL EQUIPMENT AND SUSPENSION MAGLEV BAA-90-1, Contract No. DTFR53-91-C-00078

This letter provides Battelle's inputs to PBQ&D's final report entitled "Maglev-Rail Intermodal Equipment and Suspension Study - Volume II" under the above-referenced contract number.

SUSPENSION DESIGN

To conduct a ride quality analysis, Maglev and intermodal car suspension parameters must first be defined. A preliminary suspension design was therefore generated to provide these parameters, based on established engineering practices in passenger rail vehicle design.

For the Maglev vehicle, a secondary suspension was assumed at each of the five magnet support frames (unsprung masses) of the HSST 300 vehicle. A 1 Hz vertical natural frequency was assumed for the loaded Maglev car (23,350 kg sprung car body mass) with 25 percent of critical damping. This combination would provide good ride quality for the Maglev vehicle on its normal guideway. Natural frequencies of other rigid-body modes would range from 0.68 Hz (yaw) to 0.88 Hz (pitch). A first vertical body bending mode of 6.5 Hz was chosen as typical of a vehicle this long.

The 25 sets of roller tires onto which the Maglev vehicle is transferred are assumed to contact the the magnet support frames, rather than the car body, with five roller sets per frame when positioned on the intermodal car. Stiffness and damping values for the roller tires were chosen to be representative of similar automotive-type tires. A vertical deflection of about 13 mm (0.52 in.) would be typical under the loaded Maglev car.

An intermodal car secondary suspension consisting of air bags and hydraulic dampers was chosen to provide a reasonable ride quality. Preliminary analysis with a TOFC/COFC flatcar with standard freight car trucks showed a somewhat harsh ride at the Maglev passenger compartment. A vertical natural frequency of 1.4 Hz fully loaded (2.2 Hz for the empty car) with 22 percent of critical damping was chosen. An intermodal car body vertical bending mode of 3.7 Hz was also included in the analysis.

One anticipated problem with the softer intermodal car suspension is the vertical deflection under the Maglev vehicle as it is loaded or unloaded. A total deflection of 73 mm (2.89 in.) from the Maglev guideway datum would occur unl;ess some type of self-leveling action were provided.

The primary suspension of the intermodal car is assumed to be a relatively stiff set of elastomeric bushings. In its final design, this suspension would have to provide a compromise between good curving action and higher-speed truck hunting stability.

RIDE QUALITY ANALYSIS

A analysis of Maglev vehicle ride quality was conducted using the Maglev vehicle parameters for the HSST 300 EMS-type end-car and mid-car vehicles, Tables 1 and 2, and the corresponding intermodal cars, Tables 3 and 4. The computer simulation was modified to include the fifth magnet support frame of the HSST 300 design, Figure 1. Track and input geometry parameters are given in Table 5.

Results of the analysis are summarized in Tables 6 and 7 for the HSST 300 end-car and mid-car vehicles, respectively. Three different ride quality criteria are used: the PEPLAR ride comfort index, the NASA ride comfort (DISC) index, and the German Railways (Deutches Bundesbahn) W_z index for vertical or lateral ride comfort. There is rather good agreement among the three indices. Based on the model, the ride quality is predicted to be "good" or "comfortable" on BJR track geometry typical of commuter rail lines, and quite acceptable for the limited travel time expected between the interchange point and the center-city terminus.

* * * * *

Representative computer model summary tables have been included with these report sections. This completes Battelle's work on this program. If there are any questions on the enclosed material, please call me at (614) 424-4478.

Sincerely,

Donald R. Ahlbeck
Manager, Vehicle/Structures
Dynamics Projects Office

DRA:bf

TABLE 1. PARAMETERS REPRESENTING EMS-TYPE (HSST 300 END-CAR) MAGLEV VEHICLE.

MAGLEV CAR BODY MASS, MC1	=	23350.	KG
UNSPRUNG MASS (PER FRAME), MUNS	=	1280.	KG
MAGLEV CAR MASS MOMENT IN PITCH, PJC1	=	.9730E+06	KG-M**2
MAGLEV CAR MASS MOMENT IN ROLL, RJC1	=	.4167E+05	KG-M**2
MAGLEV CAR MASS MOMENT IN YAW, YJC1	=	.9670E+06	KG-M**2
MAGLEV UNSPRUNG MASS MOMENT IN ROLL, RJUNS	=	.1070E+04	KG-M**2
ROLLER TIRES (P[ER AXLE) VERTICAL STIFFNESS, KZE	=	.7000E+06	N/M,
SECONDARY SUSP. VERT. STIFFNESS (PER FRAME), KZS	=	.1860E+06	N/M
MAGLEV LEVITATION MAGNET DAMPING, CZE	=	.1400E+04	N-SEC/M
SECONDARY SUSPENSION DAMPING (PER FRAME), CZS	=	.1480E+05	N/M
ROLLER TIRES (PER AXLE) LATERAL STIFFNESS, KYE	=	.4700E+06	N/M,
SECONDARY SUSPENSION LAT. STIFF. (PER FRAME), KYS	=	.9300E+05	N/M
ROLLER TIRES (PER AXLE) LATERAL DAMPING, CYE	=	.1150E+04	N-S/M,
SECONDARY SUSP. LAT. DAMPING (PER FRAME), CYS	=	.1050E+05	N-S/M
ROLLER TIRES AVE. LATERAL, FROM C-LINE, AKE	=	0.546	M
VERTICAL SUSPENSION LATERAL, FROM C-LINE, AKS	=	1.190	M
CAR OVERALL LENGTH, LOV1	=	22.00	M
FRONT END OF CAR TO C.G., LCG1	=	11.00	M
ROLLER TIRE SETS (AXLES) CENTER-TO-CENTER, LMAG	=	0.79	M
DISTANCE FORWARD, CAR CG TO FRAME 1	=	6.90	M
DISTANCE FORWARD, CAR CG TO FRAME 2	=	2.95	M
DISTANCE FORWARD, CAR CG TO FRAME 3	=	-1.00	M
DISTANCE FORWARD, CAR CG TO FRAME 4	=	-4.95	M
DISTANCE FORWARD, CAR CG TO FRAME 5	=	-8.90	M
HEIGHT, CAR C.G. TO MAGLEV VEHICLE C.G., HMC1	=	2.000	M
HEIGHT, CAR C.G. TO 2nd SUSPENSION, HS	=	1.050	M
HEIGHT, CAR C.G. TO MAGLEV UNSPRUNG C.G., HU	=	.750	M
HEIGHT, CAR C.G. TO ROLLER TIRE TOPS, HE	=	.165	M
CAR BODY FIRST BENDING MODE NATURAL FREQ., FNC1	=	6.5	HZ
CAR BODY FIRST BENDING MODE DAMPING RATIO, ZETC1	=	.0200	
NUMBER OF ROLLER TIRE SETS PER FRAME	=	5	

TABLE 2. PARAMETERS REPRESENTING EMS-TYPE (HSST 300 MID-CAR) MAGLEV VEHICLE.

MAGLEV CAR BODY MASS, MC1	=	23350. KG
UNSPRUNG MASS (PER FRAME), MUNS	=	1280. KG
MAGLEV CAR MASS MOMENT IN PITCH, PJC1	=	.8080E+06 KG-M**2
MAGLEV CAR MASS MOMENT IN ROLL, RJC1	=	.4167E+05 KG-M**2
MAGLEV CAR MASS MOMENT IN YAW, YJC1	=	.8020E+06 KG-M**2
MAGLEV UNSPRUNG MASS MOMENT IN ROLL, RJUNS	=	.1070E+04 KG-M**2
ROLLER TIRES (P[ER AXLE) VERTICAL STIFFNESS, KZE	=	.7000E+06 N/M,
SECONDARY SUSP. VERT. STIFFNESS (PER FRAME), KZS	=	.1860E+06 N/M
MAGLEV LEVITATION MAGNET DAMPING, CZE	=	.1400E+04 N-SEC/M
SECONDARY SUSPENSION DAMPING (PER FRAME), CZS	=	.1480E+05 N/M
ROLLER TIRES (PER AXLE) LATERAL STIFFNESS, KYE	=	.4700E+06 N/M,
SECONDARY SUSPENSION LAT. STIFF. (PER FRAME), KYS	=	.9300E+05 N/M
ROLLER TIRES (PER AXLE) LATERAL DAMPING, CYE	=	.1150E+04 N-S/M,
SECONDARY SUSP. LAT. DAMPING (PER FRAME), CYS	=	.1050E+05 N-S/M
ROLLER TIRES AVE. LATERAL, FROM C-LINE, AKE	=	0.546 M
VERTICAL SUSPENSION LATERAL, FROM C-LINE, AKS	=	1.190 M
CAR OVERALL LENGTH, LOV1	=	20.00 M
FRONT END OF CAR TO C.G., LCG1	=	10.00 M
ROLLER TIRE SETS (AXLES) CENTER-TO-CENTER, LMAG	=	0.79 M
DISTANCE FORWARD, CAR CG TO FRAME 1	=	7.90 M
DISTANCE FORWARD, CAR CG TO FRAME 2	=	3.95 M
DISTANCE FORWARD, CAR CG TO FRAME 3	=	0.00 M
DISTANCE FORWARD, CAR CG TO FRAME 4	=	-3.95 M
DISTANCE FORWARD, CAR CG TO FRAME 5	=	-7.90 M
HEIGHT, CAR C.G. TO MAGLEV VEHICLE C.G., HMC1	=	2.000 M
HEIGHT, CAR C.G. TO 2nd SUSPENSION, HS	=	1.050 M
HEIGHT, CAR C.G. TO MAGLEV UNSPRUNG C.G., HU	=	.750 M
HEIGHT, CAR C.G. TO ROLLER TIRE TOPS, HE	=	.165 M
CAR BODY FIRST BENDING MODE NATURAL FREQ., FNC1	=	8.0 HZ
CAR BODY FIRST BENDING MODE DAMPING RATIO, ZETC1	=	.0200
NUMBER OF ROLLER TIRE SETS PER FRAME	=	5

TABLE 3. INTERMODAL CAR PARAMETERS USED WITH HSST 300 END-CAR MAGLEV VEHICLE.

CAR BODY MASS, MCAR	=	16940. KG
TRUCK FRAME/BOLSTER MASS, MTF	=	1500. KG
SIDE FRAME/EQUALIZER BEAM MASS,MSF	=	600. KG
AXLE, BRAKE DISK, ETC., WAXL	=	950. KG
CAR BODY MASS MOMENT IN PITCH, PJC2	=	.7613E+06 KG-M**2
CAR BODY MASS MOMENT IN ROLL, RJC2	=	.1410E+05 KG-M**2
CAR BODY MASS MOMENT IN YAW, YJC2	=	.7740E+06 KG-M**2
TRUCK FRAME MASS MOMENT IN PITCH, PJTF	=	.5000E+03 KG-M**2
TRUCK FRAME MASS MOMENT IN ROLL, RJTF	=	.1125E+04 KG-M**2
TRUCK FRAME MASS MOMENT IN YAW, YJTF	=	.6600E+03 KG-M**2
WHEELSET MASS MOMENT IN ROLL, RJA	=	.3400E+03 KG-M**2
VERTICAL PRIMARY SUSP. STIFFNESS, PER TRUCK, KZ1	=	.1200E+09 N/M
VERT. SECONDARY SUSP. STIFFNESS, PER TRUCK, KZ2	=	.1560E+07 N/M
LATERAL PRIMARY SUSP. STIFFNESS, PER TRUCK, KY1	=	.7200E+08 N/M
LAT. SECONDARY SUSP. STIFFNESS, PER TRUCK, KY2	=	.1040E+07 N/M
PRIMARY SUSP. YAW STIFFNESS, PER TRUCK, KPSI1	=	.1000E+06 N-M/RAD
PRIMARY SUSP. RACKING STIFFNESS, PER TRUCK, KRACK	=	.1000E+06 N-M/RAD
VERTICAL PRIMARY SUSP. DAMPING, PER TRUCK, CZ1	=	.1750E+06 N-S/M
VERT. SECONDARY SUSP. DAMPING, PER TRUCK, CZ2	=	.7660E+05 N-S/M
LATERAL PRIMARY SUSP. DAMPING, PER TRUCK, CY1	=	.1000E+06 N-S/M
LATERAL SECONDARY SUSP.DAMPING, PER TRUCK, CY2	=	.6250E+05 N-S/M
PRIMARY SUSPENSION YAW DAMPING, PER TRUCK, CPSI1	=	.1000E+04 N-M-S/RAD
PRIMARY SUSP. RACKING DAMPING, PER TRUCK, CRACK	=	.1000E+04 N-M-S/RAD
TRUCK C-LINE TO WHEEL/RAIL CONTACT, AW1	=	.756 M
TRUCK CENTERLINE TO PRIMARY SUSPENSION, AK1	=	1.000 M
TRUCK C-LINE TO SECONDARY SPRINGS, AK2	=	1.154 M
TRUCK CENTERLINE TO PRIMARY DAMPING, AC1	=	1.000 M
TRUCK CENTERLINE TO SECONDARY DAMPING, AC2	=	1.105 M
OVERALL LENGTH OF INTERMODAL CAR, LOV2	=	23.220 M
FRONT OF INTERMODAL CAR TO MAGLEV CAR C.G., LCG1P	=	12.220 M
LEAD TRUCK CENTER TO CAR BODY C.G., LCG2	=	11.610 M
TRUCK CENTER SPACING, LTRK	=	15.910 M
TRUCK AXLE SPACING, LAXL	=	1.727 M
HEIGHT, RAIL TO WHEELSET C.G., HA	=	.305 M
HEIGHT, RAIL TO PRIMARY SUSPENSION, HK1	=	.305 M
HEIGHT, RAIL TO TRUCK FRAME C.G., HTF	=	.425 M
HEIGHT, RAIL TO SECONDARY SUSPENSION, HK2	=	.800 M
HEIGHT, RAIL TO CAR BODY C.G., HMC2	=	.750 M
INTERMODAL CAR BODY BENDING FREQUENCY, FNC2	=	3.7 HZ
BODY BENDING DAMPING RATIO, ZETC2	=	.020

TABLE 4. INTERMODAL CAR PARAMETERS USED WITH HSST 300 MID-CAR MAGLEV VEHICLE.

CAR BODY MASS, MCAR	=	14680. KG
TRUCK FRAME/BOLSTER MASS, MTF	=	1500. KG
SIDE FRAME/EQUALIZER BEAM MASS,MSF	=	600. KG
AXLE, BRAKE DISK, ETC., WAXL	=	950. KG
CAR BODY MASS MOMENT IN PITCH, PJC2	=	.4892E+06 KG-M**2
CAR BODY MASS MOMENT IN ROLL, RJC2	=	.1220E+05 KG-M**2
CAR BODY MASS MOMENT IN YAW, YJC2	=	.5010E+06 KG-M**2
TRUCK FRAME MASS MOMENT IN PITCH, PJTF	=	.5000E+03 KG-M**2
TRUCK FRAME MASS MOMENT IN ROLL, RJTF	=	.1125E+04 KG-M**2
TRUCK FRAME MASS MOMENT IN YAW, YJTF	=	.6600E+03 KG-M**2
WHEELSET MASS MOMENT IN ROLL, RJA	=	.3400E+03 KG-M**2
VERTICAL PRIMARY SUSP. STIFFNESS, PER TRUCK, KZ1	=	.1200E+09 N/M
VERT. SECONDARY SUSP. STIFFNESS, PER TRUCK, KZ2	=	.1490E+07 N/M
LATERAL PRIMARY SUSP. STIFFNESS, PER TRUCK, KY1	=	.7200E+08 N/M
LAT. SECONDARY SUSP. STIFFNESS, PER TRUCK, KY2	=	.9920E+06 N/M
PRIMARY SUSP. YAW STIFFNESS, PER TRUCK, KPSI1	=	.1000E+06 N-M/RAD
PRIMARY SUSP. RACKING STIFFNESS, PER TRUCK, KRACK	=	.1000E+06 N-M/RAD
VERTICAL PRIMARY SUSP. DAMPING, PER TRUCK, CZ1	=	.1750E+06 N-S/M
VERT. SECONDARY SUSP. DAMPING, PER TRUCK, CZ2	=	.7290E+05 N-S/M
LATERAL PRIMARY SUSP. DAMPING, PER TRUCK, CY1	=	.1000E+06 N-S/M
LATERAL SECONDARY SUSP.DAMPING, PER TRUCK, CY2	=	.5950E+05 N-S/M
PRIMARY SUSPENSION YAW DAMPING, PER TRUCK, CPSI1	=	.1000E+04 N-M-S/RAD
PRIMARY SUSP. RACKING DAMPING, PER TRUCK, CRACK	=	.1000E+04 N-M-S/RAD
TRUCK C-LINE TO WHEEL/RAIL CONTACT, AW1	=	.756 M
TRUCK CENTERLINE TO PRIMARY SUSPENSION, AK1	=	1.000 M
TRUCK C-LINE TO SECONDARY SPRINGS, AK2	=	1.154 M
TRUCK CENTERLINE TO PRIMARY DAMPING, AC1	=	1.000 M
TRUCK CENTERLINE TO SECONDARY DAMPING, AC2	=	1.105 M
OVERALL LENGTH OF INTERMODAL CAR, LOV2	=	20.000 M
FRONT OF INTERMODAL CAR TO MAGLEV CAR C.G., LCG1P	=	10.000 M
LEAD TRUCK CENTER TO CAR BODY C.G., LCG2	=	10.000 M
TRUCK CENTER SPACING, LTRK	=	13.900 M
TRUCK AXLE SPACING, LAXL	=	1.727 M
HEIGHT, RAIL TO WHEELSET C.G., HA	=	.305 M
HEIGHT, RAIL TO PRIMARY SUSPENSION, HK1	=	.305 M
HEIGHT, RAIL TO TRUCK FRAME C.G., HTF	=	.425 M
HEIGHT, RAIL TO SECONDARY SUSPENSION, HK2	=	.800 M
HEIGHT, RAIL TO CAR BODY C.G., HMC2	=	.750 M
INTERMODAL CAR BODY BENDING FREQUENCY, FNC2	=	5.0 HZ
BODY BENDING DAMPING RATIO, ZETC2	=	.020

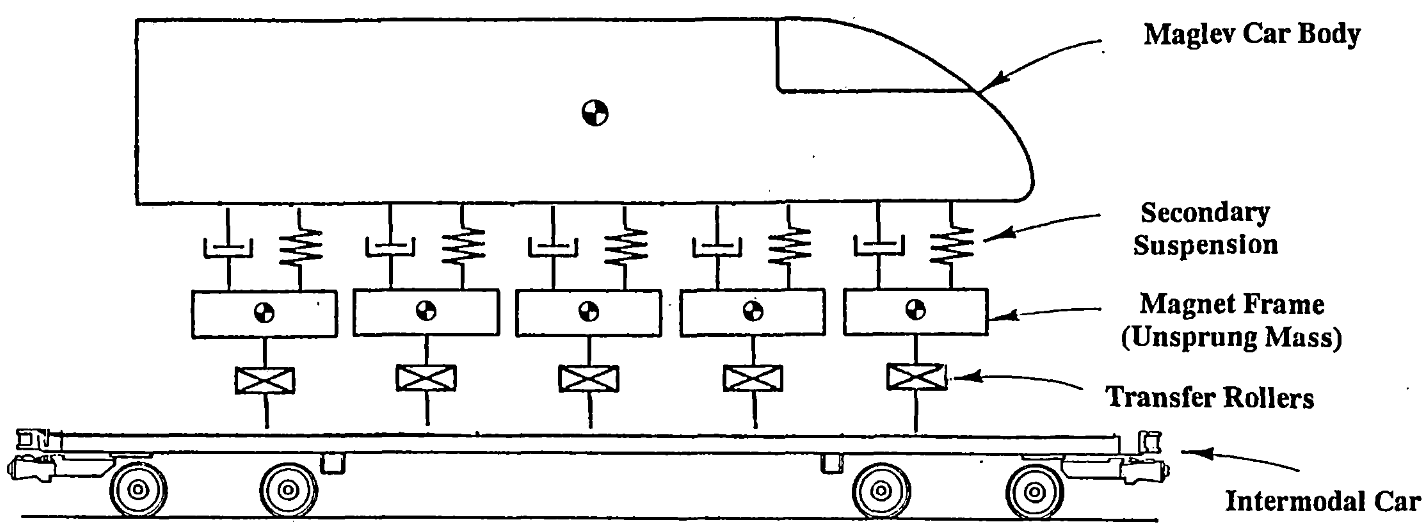


Figure 1. Sketch of Maglev Vehicle/Intermodal Car Model.

TABLE 5. TRACK PARAMETERS AND TRACK GEOMETRY RANDOM POWER SPECTRA.

WHEEL/RAIL AND TRACK PARAMETERS, PER WHEEL --

TRACK VERTICAL STIFFNESS, KZR	= .7000E+08 N/M
TRACK VERTICAL DAMPING, CZR	= .4380E+05 N-S/M
RAIL/TIE EFFECTIVE MASS, MRP	= 891.3 kG
TRACK VERTICAL MODULUS, UTRK	= .3450E+08 N/M/M
RAIL LENGTH, LR	= 11.890 M
TRACK LATERAL STIFFNESS, KL	= .1750E+08 N/M
TRACK LATERAL DAMPING, CL	= .3450E+05 N-S/M
WHEEL/RAIL LONG. CREEP COEFF., F11	= .4500E+07 N
WHEEL/RAIL LAT. CREEP COEFF., F22	= .4000E+07 N
WHEEL/RAIL SPIN/LAT. CREEP COEFF., F23	= .7900E+04 N-M
NOMINAL FLANGE CLEARANCE, DLYFLG	= .009 M
AVERAGE WHEEL CONICITY, LAM	= .050

TRACK RANDOM GEOMETRY PARAMETERS --

	CON1	CON2	N1	N2	WVLL	BSPEC
SURFACE	.3861E-05	.1869E-07	.910	3.590	7.3	20.0
ALIGNMENT	.2763E-07	.7137E-08	2.620	3.150	12.7	20.0
CROSS LEVEL	.6954E-05	.4829E-07	.810	2.520	18.3	20.0

FIRST 16 SPECTRAL COMPONENTS OF RAIL LENGTH --

SURFACE --

.1392E-03	.8299E-04	.4719E-05	.2104E-05	.3657E-06	.6076E-06
.1599E-06	.3500E-06	.4306E-06	.3933E-06	.1835E-06	.9851E-07
.0000E+00	.0000E+00	.0000E+00	.0000E+00		

ALIGNMENT --

.4916E-04	.4916E-05	.7865E-06	.3146E-06	.0000E+00	.0000E+00
.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
.0000E+00	.0000E+00	.0000E+00	.0000E+00		

CROSS LEVEL --

.1599E-03	.8199E-04	.1105E-04	.1105E-05	.1834E-05	.3932E-06
.5053E-06	.2654E-06	.1105E-05	.2654E-06	.2969E-06	.6980E-07
.0000E+00	.0000E+00	.0000E+00	.0000E+00		

Table 6. Ride Quality Assessment of EMS-Type HSST 300 End-Car on Premium-Truck Intermodal Flatcar, Good BJR Track.

End Car	Ride Quality Indices			
Speed (kph)	PEPLAR	NASA DISC	W_z (vert.)	W_z (lat.)
50	1.51	1.07	2.13	1.77
75	1.61	1.36	2.14	2.12
100	1.65	1.51	2.18	2.24
125	1.70	1.82	2.29	2.27
150	1.84	2.29	2.50	2.35

Note: 150(f) denotes 150 kph with hard wheel/rail flange contact.

Table 7. Ride Quality Assessment of EMS-Type HSST 300 Mid-Car on Premium-Truck Intermodal Flatcar, Good BJR Track.

Mid Car	Ride Quality Indices			
Speed (kph)	PEPLAR	NASA DISC	W_z (vert.)	W_z (lat.)
50	1.41	0.84	2.11	1.45
75	1.51	1.09	2.22	1.77
100	1.56	1.44	2.24	1.98
125	1.63	1.62	2.27	2.12
150	1.73	1.91	2.36	2.26

Ride Quality Ratings:

Wz	Condition of Ride
1	"Excellent"
2	"Good"
3	"Satisfactory"
4	"Car in Working Order"
5	"Dangerous"

Peplar	Comfort Scale
1	Very comfortable
2	Comfortable
3	Somewhat comfortable
4	Neutral
5	Somewhat uncomfortable
6	Uncomfortable
7	Very uncomfortable

NASA DISC from 1 to 6, where 6 = "High degree of discomfort".

RUN NUMBER 203, SPEED = 150. KPH
EMS-TYPE MAGLEV VEHICLE (HSST 300 END CAR), INTERMODAL CAR ON GOOD BJR TRACK

SUMMARY OF 3rd-OCTAVE AND BROAD-BAND RMS ANALYSIS -- SURFACE INPUT

FMIN (HZ)	TO FMAX (HZ)	AZC1F (mG)	AZC1 (mG)	AZC1R (mG)	AZC2F (mG)	AZC2 (mG)	AZC2R (mG)	FZW1 (kN)	FZE1 (kN)	FZS1 (kN)	ATHEC1 (R/S2)
.50	.63	7.2	3.5	1.5	3.4	1.6	1.6	.72	.27	.56	.005
.63	.79	10.6	6.2	1.8	3.6	2.8	2.8	.61	.27	.72	.006
.79	1.00	9.7	6.5	7.0	2.9	2.8	2.8	.34	.19	.61	.007
1.00	1.26	6.8	2.9	8.3	4.9	1.6	1.6	.28	.12	.43	.009
1.26	1.59	4.6	1.2	8.1	6.6	2.3	2.3	.32	.11	.29	.008
1.59	2.00	2.8	3.1	7.7	6.7	6.8	6.8	.26	.08	.17	.006
2.00	2.52	3.7	4.2	6.0	11.0	13.4	13.4	.27	.09	.19	.003
2.52	3.17	3.4	3.0	3.9	17.4	16.0	16.0	.36	.12	.21	.002
3.17	4.00	3.0	1.0	3.0	25.7	11.3	11.3	.56	.12	.23	.004
4.00	5.04	3.3	1.3	2.4	30.5	3.5	3.5	.80	.13	.23	.003
5.04	6.35	3.2	5.3	4.8	47.8	8.1	8.1	1.33	.18	.34	.003
6.35	8.00	9.4	15.4	24.4	73.6	23.5	23.5	3.19	.42	.61	.007
8.00	10.08	3.3	4.3	6.7	40.1	14.9	14.9	1.71	.25	.27	.003
10.08	12.70	2.3	3.3	3.9	76.5	21.5	21.5	2.31	.24	.20	.002
12.70	16.00	.9	.9	1.0	83.5	19.3	19.3	3.00	.12	.08	.001
16.00	20.16	.4	.3	.3	76.6	16.7	16.7	3.47	.06	.03	.000
20.16	25.40	.2	.2	.2	111.0	25.5	25.5	5.77	.05	.02	.000
25.40	32.00	.2	.1	.2	202.1	46.6	46.6	11.94	.05	.01	.000

RMS ACCELERATIONS OVER .50 TO 32.00 HZ FREQUENCY BAND ----

MAGLEV FRONT VERTICAL ACCEL., AZC1F, G RMS = .022
MAGLEV CENTER VERTICAL ACCEL., AZC1, G RMS = .021
MAGLEV REAR VERTICAL ACCEL., AZC1R, G RMS = .031
PLATFORM FRONT VERTICAL ACCEL., AZC2F, G RMS = .289
PLATFORM CENTER VERTICAL ACCEL., AZC2, G RMS = .074
PLATFORM REAR VERTICAL ACCEL., AZC2R, G RMS = .074
LEADING WHEEL DYNAMIC FORCE, FZW1, kN RMS = 14.82
ROLLER TIRE SET DYN. FORCE, FZE1, kN RMS = .78
MAGLEV 2nd SUSP. DYN. FORCE, FZS1, kN RMS = 1.51
MAGLEV CAR BODY PITCH ACCEL., RAD/SEC2 RMS = .0199
FRONT ISO-WEIGHTED ACCELERATION, G RMS = .015
CENTER ISO-WEIGHTED ACCELERATION, G RMS = .018
REAR ISO-WEIGHTED ACCELERATION, G RMS = .028
FRONT NASA-WEIGHTED ACCELERATION, G RMS = .012
CENTER NASA-WEIGHTED ACCELERATION, G RMS = .015
REAR NASA-WEIGHTED ACCELERATION, G RMS = .023
NASA-WEIGHTED PITCH ACCELERATION, R/S2 RMS = .014

RIDE COMFORT INDICES OVER .50 TO 32.00 HZ FREQUENCY BAND ----

FRONT RIDE COMFORT (WZ RATING) = 2.13
CENTER RIDE COMFORT (WZ RATING) = 2.19
REAR RIDE COMFORT (WZ RATING) = 2.50
NASA RIDE COMFORT COMPONENT, DVERT1 (FRONT) = .794
NASA RIDE COMFORT COMPONENT, DVERT2 (CENTER) = .918
NASA RIDE COMFORT COMPONENT, DVERT3 (REAR) = 1.261
NASA RIDE COMFORT COMPONENT, DPITCH = .124

PROGRAM INTRMDLH - LATERAL/ROLL/YAW DOFs ONLY, VERSION OF 7-06-92
INPUT DATA FILE = D:\BRIEF\IMODH11.DAT
RUN NUMBER 203, SPEED = 150. KPH
EMS-TYPE MAGLEV VEHICLE (HSST 300 END CAR), INTERMODAL CAR ON GOOD BJR TRACK

SUMMARY OF 3rd-OCTAVE AND BROAD-BAND RMS ANALYSIS -- ALIGNMENT (FLANGING)

FMIN (HZ)	TO FMAX (HZ)	AYC1F (mG)	AYC1 (mG)	AYC1R (mG)	FYS1 (kN)	FYE1 (kN)	FYW (kN)	FZS1 (Kn)	FZE1 (kN)	FZW (kN)	VPHI1 (R/S)
.50	.63	5.85	3.10	6.46	.52	.17	1.78	.50	.31	18.73	.01
.63	.79	6.60	2.00	5.93	.43	.21	1.40	.27	.13	15.47	.00
.79	1.00	4.57	.77	4.49	.22	.21	1.18	.10	.05	12.78	.00
1.00	1.26	1.72	.12	2.24	.06	.10	1.02	.04	.05	10.55	.00
1.26	1.59	.70	.17	1.25	.02	.06	.92	.03	.04	8.74	.00
1.59	2.00	2.45	.42	4.08	.01	.05	.87	.08	.05	7.22	.00
2.00	2.52	5.03	.86	8.32	.03	.05	.88	.13	.06	5.97	.00
2.52	3.17	3.81	.75	6.50	.02	.03	.89	.09	.06	5.04	.00
3.17	4.00	.83	.15	1.30	.00	.01	.85	.02	.02	4.18	.00
4.00	5.04	1.77	.50	3.27	.01	.03	.84	.03	.05	3.40	.00
5.04	6.35	.90	.34	1.85	.01	.02	.82	.02	.03	2.74	.00
6.35	8.00	.42	.18	.93	.00	.01	1.08	.01	.01	2.97	.00
8.00	10.08	.11	.04	.23	.00	.00	.79	.00	.00	1.80	.00
10.08	12.70	.04	.02	.09	.00	.00	.86	.00	.00	1.60	.00
12.70	16.00	.04	.01	.07	.00	.00	1.14	.00	.00	1.46	.00
16.00	20.16	.13	.02	.18	.00	.00	2.23	.01	.00	1.60	.00
20.16	25.40	.13	.02	.17	.00	.00	2.02	.01	.00	.93	.00
25.40	32.00	.05	.01	.06	.00	.00	1.09	.00	.00	.34	.00

RMS ACCELERATIONS OVER .50 TO 32.00 HZ FREQUENCY BAND ----

MAGLEV FRONT LATERAL ACCEL., AYC1F, G RMS	=	.012
MAGLEV CENTER LATERAL ACCEL., AYC1, G RMS	=	.004
MAGLEV REAR LATERAL ACCEL., AYC1R, G RMS	=	.016
MAGLEV ROLL ACCELERATION, APHI1, RAD/SEC2 RMS	=	.079
INTERMODAL CAR ROLL ACCEL., APHI2, RAD/SEC2 RMS	=	.123
MAGLEV ROLL RATE, VPHI1, RAD/SEC RMS	=	.010
INTERMODAL ROLL RATE, VPHI2, RAD/SEC RMS	=	.005
FRONT ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.012
CENTER ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.004
REAR ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.014
FRONT NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.009
CENTER NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.003
REAR NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.012
MAGLEV NASA-WEIGHTED ROLL ACCEL., R/S2 RMS	=	.059
CAR NASA-WEIGHTED ROLL ACCEL., R/S2 RMS	=	.069

```
PROGRAM INTRMDLH -  LATERAL/ROLL/YAW DOFs ONLY, VERSION OF 7-06-92
INPUT DATA FILE =  D:\BRIEF\IMODH11.DAT
RUN NUMBER  203, SPEED = 150. KPH
EMS-TYPE MAGLEV VEHICLE (HSST 300 END CAR), INTERMODAL CAR ON GOOD BJR TRACK


   RMS FORCES OVER   .50 TO 32.00 HZ FREQUENCY BAND ----

   MAGLEV 2nd SUSP. DYN. FORCE, FYS1, kN RMS         =   .72
   MAGLEV 2nd SUSP. DYN. FORCE, FZS1, kN RMS         =   .60
   MAGLEV PRIMARY SUSP. DYN. FORCE, FYE1, kN RMS     =   .38
   MAGLEV PRIMARY SUSP. DYN. FORCE, FZE1, kN RMS     =   .37
   LEADING WHEEL DYNAMIC FORCE, FYW1, kN RMS         =  5.18
   LEADING WHEEL DYNAMIC FORCE, FZW1, kN RMS         = 33.33


   RIDE COMFORT INDICES OVER   .50 TO 32.00 HZ FREQUENCY BAND ----

   FRONT RIDE COMFORT (WZ RATING)                    =  1.85
   CENTER RIDE COMFORT (WZ RATING)                   =  1.26
   REAR RIDE COMFORT (WZ RATING)                     =  2.07
   NASA RIDE COMFORT COMPONENT, DLAT1 (FRONT)        =  .744
   NASA RIDE COMFORT COMPONENT, DLAT2 (CENTER)       =  .219
   NASA RIDE COMFORT COMPONENT, DLAT3 (REAR)         =  .956
   NASA RIDE COMFORT COMPONENT, DROLL1 (MAGLEV)      =  .142
   NASA RIDE COMFORT COMPONENT, DROLL2 (CAR)         =  .166
```

PROGRAM INTRMDLH - LATERAL/ROLL/YAW DOFs ONLY, VERSION OF 7-06-92
INPUT DATA FILE = D:\BRIEF\IMODH11.DAT
RUN NUMBER 203, SPEED = 150. KPH
EMS-TYPE MAGLEV VEHICLE (HSST 300 END CAR), INTERMODAL CAR ON GOOD BJR TRACK

SUMMARY OF 3rd-OCTAVE AND BROAD-BAND RMS ANALYSIS -- CROSS LEVEL INPUT

FMIN (HZ)	TO FMAX (HZ)	AYC1F (mG)	AYC1 (mG)	AYC1R (mG)	FYS1 (kN)	FYE1 (kN)	FYW (kN)	FZS1 (Kn)	FZE1 (kN)	FZW (kN)	VPHI1 (R/S)
.50	.63	1.77	.97	1.37	.15	.05	3.00	.09	.10	.93	.00
.63	.79	2.06	.71	1.46	.13	.07	3.05	.06	.06	.91	.00
.79	1.00	1.44	.31	1.24	.07	.07	3.11	.03	.03	.89	.00
1.00	1.26	.51	.05	.66	.02	.03	3.17	.01	.02	.89	.00
1.26	1.59	.31	.08	.57	.01	.03	3.24	.01	.03	.95	.00
1.59	2.00	2.18	.43	3.79	.01	.06	3.29	.02	.11	1.07	.00
2.00	2.52	6.56	.98	10.69	.02	.09	3.29	.06	.24	1.23	.00
2.52	3.17	6.88	.87	10.87	.03	.05	2.91	.08	.22	1.18	.00
3.17	4.00	1.46	.18	2.25	.01	.01	2.50	.02	.05	1.11	.00
4.00	5.04	4.41	.78	7.01	.02	.04	2.19	.06	.16	1.21	.00
5.04	6.35	2.39	.56	4.03	.01	.04	2.37	.03	.09	1.46	.00
6.35	8.00	1.98	.71	3.95	.01	.05	5.98	.01	.11	4.22	.00
8.00	10.08	.15	.07	.34	.00	.00	1.81	.00	.01	1.36	.00
10.08	12.70	.09	.03	.19	.00	.00	2.44	.00	.01	1.99	.00
12.70	16.00	.04	.01	.08	.00	.00	1.38	.00	.00	1.46	.00
16.00	20.16	.14	.03	.20	.00	.00	2.21	.01	.01	3.14	.00
20.16	25.40	.11	.02	.14	.00	.00	1.15	.01	.01	3.39	.00
25.40	32.00	.05	.01	.06	.00	.00	.53	.00	.01	4.39	.00

RMS ACCELERATIONS OVER .50 TO 32.00 HZ FREQUENCY BAND ----

MAGLEV FRONT LATERAL ACCEL., AYC1F, G RMS	=	.012
MAGLEV CENTER LATERAL ACCEL., AYC1, G RMS	=	.002
MAGLEV REAR LATERAL ACCEL., AYC1R, G RMS	=	.018
MAGLEV ROLL ACCELERATION, APHI1, RAD/SEC2 RMS	=	.067
INTERMODAL CAR ROLL ACCEL., APHI2, RAD/SEC2 RMS	=	.551
MAGLEV ROLL RATE, VPHI1, RAD/SEC RMS	=	.004
INTERMODAL ROLL RATE, VPHI2, RAD/SEC RMS	=	.011
FRONT ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.009
CENTER ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.002
REAR ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.014
FRONT NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.009
CENTER NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.002
REAR NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.014
MAGLEV NASA-WEIGHTED ROLL ACCEL., R/S2 RMS	=	.043
CAR NASA-WEIGHTED ROLL ACCEL., R/S2 RMS	=	.123

```
PROGRAM INTRMDLH -  LATERAL/ROLL/YAW DOFs ONLY, VERSION OF 7-06-92
INPUT DATA FILE =  D:\BRIEF\IMODH11.DAT
RUN NUMBER  203, SPEED = 150. KPH
EMS-TYPE MAGLEV VEHICLE (HSST 300 END CAR), INTERMODAL CAR ON GOOD BJR TRACK

   RMS FORCES OVER   .50 TO 32.00 HZ FREQUENCY BAND ----

   MAGLEV 2nd SUSP. DYN. FORCE, FYS1, kN RMS           =   .21
   MAGLEV 2nd SUSP. DYN. FORCE, FZS1, kN RMS           =   .17
   MAGLEV PRIMARY SUSP. DYN. FORCE, FYE1, kN RMS       =   .18
   MAGLEV PRIMARY SUSP. DYN. FORCE, FZE1, kN RMS       =   .43
   LEADING WHEEL DYNAMIC FORCE, FYW1, kN RMS           = 12.19
   LEADING WHEEL DYNAMIC FORCE, FZW1, kN RMS           =  8.91

   RIDE COMFORT INDICES OVER   .50 TO 32.00 HZ FREQUENCY BAND ----

   FRONT RIDE COMFORT (WZ RATING)                      =  1.98
   CENTER RIDE COMFORT (WZ RATING)                     =  1.17
   REAR RIDE COMFORT (WZ RATING)                       =  2.29
   NASA RIDE COMFORT COMPONENT, DLAT1 (FRONT)          =  .778
   NASA RIDE COMFORT COMPONENT, DLAT2 (CENTER)         =  .131
   NASA RIDE COMFORT COMPONENT, DLAT3 (REAR)           = 1.070
   NASA RIDE COMFORT COMPONENT, DROLL1 (MAGLEV)        =  .104
   NASA RIDE COMFORT COMPONENT, DROLL2 (CAR)           =  .344
```

RUN NUMBER 204, SPEED = 150. KPH
EMS-TYPE MAGLEV VEHICLE (HSST 300 MID CAR), INTERMODAL CAR ON GOOD BJR TRACK

SUMMARY OF 3rd-OCTAVE AND BROAD-BAND RMS ANALYSIS -- SURFACE INPUT

FMIN (HZ)	TO FMAX (HZ)	AZC1F (mG)	AZC1 (mG)	AZC1R (mG)	AZC2F (mG)	AZC2 (mG)	AZC2R (mG)	FZW1 (kN)	FZE1 (kN)	FZS1 (kN)	ATHEC1 (R/S2)
.50	.63	1.9	1.6	2.0	1.2	1.2	1.2	.08	.06	.09	.001
.63	.79	4.2	3.7	5.3	2.1	2.3	2.3	.15	.10	.21	.004
.79	1.00	6.3	4.9	9.4	2.4	3.0	3.0	.18	.14	.32	.008
1.00	1.26	5.6	2.5	7.9	3.5	2.8	2.8	.10	.13	.29	.008
1.26	1.59	5.2	1.1	6.9	6.7	4.3	4.3	.09	.13	.27	.008
1.59	2.00	6.2	3.2	6.3	12.2	8.0	8.0	.20	.10	.30	.007
2.00	2.52	7.0	5.0	4.7	18.0	13.5	13.5	.35	.04	.31	.004
2.52	3.17	6.0	4.3	3.2	22.9	16.3	16.3	.43	.09	.28	.002
3.17	4.00	5.6	2.5	3.1	37.0	13.0	13.0	.61	.10	.33	.005
4.00	5.04	6.0	2.1	2.8	42.2	7.5	7.5	.86	.09	.32	.006
5.04	6.35	5.6	3.2	2.1	41.8	13.1	13.1	1.19	.14	.31	.003
6.35	8.00	14.4	10.6	15.7	82.0	18.2	18.2	3.04	.42	.64	.011
8.00	10.08	10.9	5.0	11.4	45.3	10.8	10.8	1.61	.26	.27	.004
10.08	12.70	6.1	2.9	4.8	103.4	28.3	28.3	2.26	.30	.25	.004
12.70	16.00	2.4	.9	1.1	116.9	19.7	19.7	3.04	.17	.11	.002
16.00	20.16	.8	.3	.4	97.1	14.9	14.9	3.49	.07	.04	.001
20.16	25.40	.4	.2	.2	133.3	24.3	24.3	5.82	.06	.02	.000
25.40	32.00	.4	.1	.2	218.2	34.6	34.6	12.19	.05	.02	.000

RMS ACCELERATIONS OVER .50 TO 32.00 HZ FREQUENCY BAND ----

MAGLEV FRONT VERTICAL ACCEL., AZC1F, G RMS	= .027
MAGLEV CENTER VERTICAL ACCEL., AZC1, G RMS	= .016
MAGLEV REAR VERTICAL ACCEL., AZC1R, G RMS	= .027
PLATFORM FRONT VERTICAL ACCEL., AZC2F, G RMS	= .337
PLATFORM CENTER VERTICAL ACCEL., AZC2, G RMS	= .068
PLATFORM REAR VERTICAL ACCEL., AZC2R, G RMS	= .068
LEADING WHEEL DYNAMIC FORCE, FZW1, kN RMS	= 14.96
ROLLER TIRE SET DYN. FORCE, FZE1, kN RMS	= .71
MAGLEV 2nd SUSP. DYN. FORCE, FZS1, kN RMS	= 1.20
MAGLEV CAR BODY PITCH ACCEL., RAD/SEC2 RMS	= .0223
FRONT ISO-WEIGHTED ACCELERATION, G RMS	= .023
CENTER ISO-WEIGHTED ACCELERATION, G RMS	= .014
REAR ISO-WEIGHTED ACCELERATION, G RMS	= .022
FRONT NASA-WEIGHTED ACCELERATION, G RMS	= .019
CENTER NASA-WEIGHTED ACCELERATION, G RMS	= .012
REAR NASA-WEIGHTED ACCELERATION, G RMS	= .018
NASA-WEIGHTED PITCH ACCELERATION, R/S2 RMS	= .016

RIDE COMFORT INDICES OVER .50 TO 32.00 HZ FREQUENCY BAND ----

FRONT RIDE COMFORT (WZ RATING)	= 2.36
CENTER RIDE COMFORT (WZ RATING)	= 2.04
REAR RIDE COMFORT (WZ RATING)	= 2.33
NASA RIDE COMFORT COMPONENT, DVERT1 (FRONT)	= 1.071
NASA RIDE COMFORT COMPONENT, DVERT2 (CENTER)	= .756
NASA RIDE COMFORT COMPONENT, DVERT3 (REAR)	= 1.033
NASA RIDE COMFORT COMPONENT, DPITCH	= .140

PROGRAM INTRMDLH - LATERAL/ROLL/YAW DOFs ONLY, VERSION OF 7-06-92
INPUT DATA FILE = D:\BRIEF\IMODH12.DAT
RUN NUMBER 204, SPEED = 150. KPH
EMS-TYPE MAGLEV VEHICLE (HSST 300 MID CAR), INTERMODAL CAR ON GOOD BJR TRACK

SUMMARY OF 3rd-OCTAVE AND BROAD-BAND RMS ANALYSIS -- ALIGNMENT (FLANGING)

FMIN (HZ)	TO FMAX (HZ)	AYC1F (mG)	AYC1 (mG)	AYC1R (mG)	FYS1 (kN)	FYE1 (kN)	FYW (kN)	FZS1 (Kn)	FZE1 (kN)	FZW (kN)	VPHI1 (R/S)
.50	.63	3.14	2.18	3.00	.23	.08	1.65	.42	.28	18.54	.01
.63	.79	3.48	1.33	1.82	.19	.08	1.29	.25	.16	15.31	.00
.79	1.00	2.80	.60	1.68	.10	.08	1.11	.12	.09	12.69	.00
1.00	1.26	1.37	.11	1.25	.04	.05	1.01	.05	.05	10.54	.00
1.26	1.59	.52	.11	.71	.01	.04	.93	.02	.02	8.75	.00
1.59	2.00	1.44	.17	1.76	.01	.02	.88	.03	.02	7.27	.00
2.00	2.52	5.20	.57	6.01	.04	.06	.88	.09	.03	6.05	.00
2.52	3.17	6.04	.87	6.99	.05	.07	.91	.09	.03	5.08	.00
3.17	4.00	2.19	.44	2.71	.02	.02	.87	.04	.02	4.20	.00
4.00	5.04	.56	.17	.68	.00	.01	.83	.01	.01	3.35	.00
5.04	6.35	.75	.47	1.41	.01	.04	.83	.02	.01	2.77	.00
6.35	8.00	.15	.08	.24	.00	.01	1.06	.01	.01	2.93	.00
8.00	10.08	.15	.10	.35	.00	.01	.79	.00	.00	1.82	.00
10.08	12.70	.03	.01	.05	.00	.00	.86	.00	.00	1.60	.00
12.70	16.00	.04	.01	.06	.00	.00	1.14	.00	.00	1.46	.00
16.00	20.16	.14	.02	.15	.00	.00	2.26	.01	.00	1.63	.00
20.16	25.40	.12	.02	.12	.00	.00	2.05	.00	.00	.96	.00
25.40	32.00	.04	.01	.04	.00	.00	1.09	.00	.00	.35	.00

RMS ACCELERATIONS OVER .50 TO 32.00 HZ FREQUENCY BAND ----

MAGLEV FRONT LATERAL ACCEL., AYC1F, G RMS	=	.010
MAGLEV CENTER LATERAL ACCEL., AYC1, G RMS	=	.003
MAGLEV REAR LATERAL ACCEL., AYC1R, G RMS	=	.011
MAGLEV ROLL ACCELERATION, APHI1, RAD/SEC2 RMS	=	.072
INTERMODAL CAR ROLL ACCEL., APHI2, RAD/SEC2 RMS	=	.114
MAGLEV ROLL RATE, VPHI1, RAD/SEC RMS	=	.009
INTERMODAL ROLL RATE, VPHI2, RAD/SEC RMS	=	.004
FRONT ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.009
CENTER ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.003
REAR ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.009
FRONT NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.008
CENTER NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.002
REAR NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.009
MAGLEV NASA-WEIGHTED ROLL ACCEL., R/S2 RMS	=	.050
CAR NASA-WEIGHTED ROLL ACCEL., R/S2 RMS	=	.052

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PROGRAM INTRMDLH -  LATERAL/ROLL/YAW DOFs ONLY, VERSION OF 7-06-92
 INPUT DATA FILE =  D:\BRIEF\IMODH12.DAT
 RUN NUMBER  204, SPEED = 150. KPH
 EMS-TYPE MAGLEV VEHICLE (HSST 300 MID CAR), INTERMODAL CAR ON GOOD BJR TRACK


    RMS FORCES OVER   .50 TO 32.00 HZ FREQUENCY BAND ----

    MAGLEV 2nd SUSP. DYN. FORCE, FYS1, kN RMS         =   .33
    MAGLEV 2nd SUSP. DYN. FORCE, FZS1, kN RMS         =   .53
    MAGLEV PRIMARY SUSP. DYN. FORCE, FYE1, kN RMS     =   .19
    MAGLEV PRIMARY SUSP. DYN. FORCE, FZE1, kN RMS     =   .35
    LEADING WHEEL DYNAMIC FORCE, FYW1, kN RMS         =  5.13
    LEADING WHEEL DYNAMIC FORCE, FZW1, kN RMS         = 33.15


    RIDE COMFORT INDICES OVER   .50 TO 32.00 HZ FREQUENCY BAND ----

    FRONT RIDE COMFORT (WZ RATING)                    =  1.84
    CENTER RIDE COMFORT (WZ RATING)                   =  1.16
    REAR RIDE COMFORT (WZ RATING)                     =  1.91
    NASA RIDE COMFORT COMPONENT, DLAT1 (FRONT)        =  .674
    NASA RIDE COMFORT COMPONENT, DLAT2 (CENTER)       =  .159
    NASA RIDE COMFORT COMPONENT, DLAT3 (REAR)         =  .738
    NASA RIDE COMFORT COMPONENT, DROLL1 (MAGLEV)      =  .120
    NASA RIDE COMFORT COMPONENT, DROLL2 (CAR)         =  .125
```

PROGRAM INTRMDLH - LATERAL/ROLL/YAW DOFs ONLY, VERSION OF 7-06-92
INPUT DATA FILE = D:\BRIEF\IMODH12.DAT
RUN NUMBER 204, SPEED = 150. KPH
EMS-TYPE MAGLEV VEHICLE (HSST 300 MID CAR), INTERMODAL CAR ON GOOD BJR TRACK

SUMMARY OF 3rd-OCTAVE AND BROAD-BAND RMS ANALYSIS -- CROSS LEVEL INPUT

FMIN (HZ)	TO FMAX (HZ)	AYC1F (mG)	AYC1 (mG)	AYC1R (mG)	FYS1 (kN)	FYE1 (kN)	FYW (kN)	FZS1 (Kn)	FZE1 (kN)	FZW (kN)	VPHI1 (R/S)
.50	.63	1.17	.76	.59	.08	.02	2.97	.08	.15	.89	.00
.63	.79	1.29	.53	.34	.07	.01	3.03	.05	.11	.89	.00
.79	1.00	1.09	.27	.58	.04	.02	3.09	.03	.07	.89	.00
1.00	1.26	.52	.06	.44	.01	.02	3.17	.01	.03	.91	.00
1.26	1.59	.21	.05	.30	.00	.01	3.24	.01	.01	.96	.00
1.59	2.00	1.13	.18	1.48	.01	.02	3.32	.01	.05	1.07	.00
2.00	2.52	5.85	.63	7.09	.03	.04	3.34	.04	.18	1.23	.00
2.52	3.17	10.34	.84	12.01	.05	.04	2.93	.07	.28	1.22	.00
3.17	4.00	5.83	.43	6.63	.03	.02	2.51	.05	.15	1.15	.00
4.00	5.04	1.44	.22	1.61	.01	.02	2.16	.02	.04	1.12	.00
5.04	6.35	3.29	.76	4.01	.02	.06	2.42	.04	.09	1.60	.00
6.35	8.00	1.01	.28	1.29	.01	.03	5.89	.02	.03	3.86	.00
8.00	10.08	.21	.13	.41	.00	.01	1.82	.00	.02	1.38	.00
10.08	12.70	.06	.03	.11	.00	.00	2.44	.00	.00	1.99	.00
12.70	16.00	.04	.02	.07	.00	.00	1.39	.00	.00	1.46	.00
16.00	20.16	.14	.03	.18	.00	.01	2.25	.01	.01	3.18	.00
20.16	25.40	.08	.02	.09	.00	.00	1.19	.00	.01	3.43	.00
25.40	32.00	.04	.01	.05	.00	.00	.54	.00	.01	4.44	.00

RMS ACCELERATIONS OVER .50 TO 32.00 HZ FREQUENCY BAND ----

MAGLEV FRONT LATERAL ACCEL., AYC1F, G RMS	=	.014
MAGLEV CENTER LATERAL ACCEL., AYC1, G RMS	=	.002
MAGLEV REAR LATERAL ACCEL., AYC1R, G RMS	=	.016
MAGLEV ROLL ACCELERATION, APHI1, RAD/SEC2 RMS	=	.053
INTERMODAL CAR ROLL ACCEL., APHI2, RAD/SEC2 RMS	=	.521
MAGLEV ROLL RATE, VPHI1, RAD/SEC RMS	=	.003
INTERMODAL ROLL RATE, VPHI2, RAD/SEC RMS	=	.010
FRONT ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.010
CENTER ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.001
REAR ISO-WEIGHTED LATERAL ACCEL., G RMS	=	.011
FRONT NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.011
CENTER NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.001
REAR NASA-WEIGHTED LATERAL ACCEL., G RMS	=	.012
MAGLEV NASA-WEIGHTED ROLL ACCEL., R/S2 RMS	=	.034
CAR NASA-WEIGHTED ROLL ACCEL., R/S2 RMS	=	.122

```
PROGRAM INTRMDLH -  LATERAL/ROLL/YAW DOFs ONLY, VERSION OF 7-06-92
INPUT DATA FILE =  D:\BRIEF\IMODH12.DAT
RUN NUMBER  204, SPEED = 150. KPH
EMS-TYPE MAGLEV VEHICLE (HSST 300 MID CAR), INTERMODAL CAR ON GOOD BJR TRACK


   RMS FORCES OVER   .50 TO 32.00 HZ FREQUENCY BAND ----

   MAGLEV 2nd SUSP. DYN. FORCE, FYS1, kN RMS          =   .13
   MAGLEV 2nd SUSP. DYN. FORCE, FZS1, kN RMS          =   .15
   MAGLEV PRIMARY SUSP. DYN. FORCE, FYE1, kN RMS      =   .10
   MAGLEV PRIMARY SUSP. DYN. FORCE, FZE1, kN RMS      =   .43
   LEADING WHEEL DYNAMIC FORCE, FYW1, kN RMS          = 12.18
   LEADING WHEEL DYNAMIC FORCE, FZW1, kN RMS          =  8.83


   RIDE COMFORT INDICES OVER   .50 TO 32.00 HZ FREQUENCY BAND ----

   FRONT RIDE COMFORT (WZ RATING)                     =  2.11
   CENTER RIDE COMFORT (WZ RATING)                    =  1.10
   REAR RIDE COMFORT (WZ RATING)                      =  2.21
   NASA RIDE COMFORT COMPONENT, DLAT1 (FRONT)         =  .897
   NASA RIDE COMFORT COMPONENT, DLAT2 (CENTER)        =  .101
   NASA RIDE COMFORT COMPONENT, DLAT3 (REAR)          =  .981
   NASA RIDE COMFORT COMPONENT, DROLL1 (MAGLEV)       =  .081
   NASA RIDE COMFORT COMPONENT, DROLL2 (CAR)          =  .341
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APPENDIX E

LIST OF DRAWINGS / INFORMATION REVIEWED

APPENDIX E
LIST OF DRAWINGS / INFORMATION REVIEWED

Railroad Valuation Maps

Southern Pacific Transportation Company, Coast Division

- Drawings V-75/1 and V-75/2, V-2/1 through V-2/9

Atchison, Topeka & Santa Fe Railway Company:

- Los Angeles Division, Los Angeles Station Map, Sheets 3 and 4 of 10
- California Division, San Diego Station Map, Sheet 4 of 11

Terminal Railroad Association of St. Louis:

- Station 0+00 to Station 21+70, dated June 30, 1919, V-1/S-T.1
- Station 0+00 to Station 21+70, dated October 30, 1943, V-1/S-T.1
- Station 21+70 to Station 48+10, dated June 30, 1919, V-1/S-T.2
- Station 15+99 to Station 38+92, dated June 30, 1919, V-1/S-T.6

Pennsylvania Company, Chicago Terminal Division:

- Station 24702+00 to Station 24755+20, V-3b (Illinois)/S.T.15

New York Central Railroad Company:

- Cleveland, OH., Station 26+02 to Station 26+78, V.204.A/S.T.7b
- Cleveland, OH., Station 79+58 to Station 26+78, V.204.A/S.T.7a
- Cleveland, OH., Station 132+38 to Station 79+58, V.204A/S.T.6b
- Buffalo Terminal, Station 2307+487 to Station 2312+762, V.82/T.5
- Syracuse Division, Rochester Terminal, Station 1958+885.9 to Station 1964+165.5, V76/T5
- Syracuse Division, Rochester Terminal, Station 1953+624 to Station 1958+885.9, V76/T4
- Syracuse Division, Syracuse Terminal, Station 1504+739.5 to Station 1510+021.02, V73/4

Penn Central Transportation Company:

- Syracuse Division, Renssalaer Terminal, Station 747+188 to 754+325, V61/1

Pennsylvania Tunnel and Terminal Railroad:

- New York Terminal, Station 136+88 to Station 189+68, V-2.0/S.T.5

Pennsylvania Railroad:

- Pittsburgh Terminal, Station 5917+57 to Station 5966+62, 17.2/S.T.18
- Philadelphia Terminal Division, V1.0/S.T.2

Boston Terminal Company:

- Boston Terminal, from Fort Point Channel to Summer Street, V 1.00/S.T.1

Washington Terminal Company:

- Washington Terminal, Station 0+00 to Station 43+97.04, V13.1/1

<u>United States Geological Survey, 7.5 minute Topographic Maps</u>

<u>Miscellaneous</u>

Umbrella Shed Addition at 4th and Townsend Streets, San Francisco, California

- Drawing No. 24842, Sheets 1-3
- Drawing No. 24141, Sheets P-1, P-2 and A-1

Southern Pacific Transportation Company:

- Track Charts - San Francisco to San Jose
- Typical 2 - Track Tunnel Section
- Photographs of Stations from College Park to Paul Street

Atchison, Topeka & Santa Fe Railway Company:

- Track Charts - San Diego
- Track Charts - Los Angeles

Terminal Railroad Association of St. Louis:

- Rendering of Union Station

APPENDIX F

TELEPHONE CONVERSATIONS WITH AMTRAK OFFICIALS

Parsons Brinckerhoff

Memorandum

TO: File

FROM: Mike Gillam CMG

RE: **TELEPHONE CONVERSATION WITH MIKE TROSINO (202) 906-2617**

DATE: March 10, 1992

On this date, Vasant Patil and I talked with Mike Trosino, Senior Engineer of Clearances and Tests for Amtrak. Mike was recently promoted into this position which was formally held by Edward V. Walker, III.

The subject of the conversation was to get a better understanding of the physical clearance restrictions that exist around the United States - restrictions that resulted in the production of two clearance diagrams:

- Clearance Diagram A-05-1355 (2 sheets) - This diagram provides the maximum allowable equipment dimensions for unrestricted operation throughout the Amtrak system.
- Superliner Construction Outline - This outline provides the maximum dimensions of the bi-level passenger equipment currently operated by Amtrak.

Following is a discussion of the information gained in that conversation.

- Note 3d on Diagram A-05-1355 discusses a 12°30' curve. This degree of curvature is specified to maintain proper clearance to the contact rails located at both New York terminals (Grand Central and Penn Station). However, the clearance diagram was developed using a maximum degree of curvature of 23°00'. The present Amfleet equipment can presently negotiate a 23° curve, but is not called to do so very often. There is a wye track on the west side of Penn Station in New York that is a 22°00' curve (Empire Connection), and another wye track in Lorton, Virginia that contains a 21°00' curve, but these tracks are not used often. Mike was unsure about the existing curvature in the Boston Coach Yard tracks.
- The maximum degree of curvature on operational track is 12°30', corresponding to a minimum No. 8 turnout, at New York's Penn Station. A maximum 12°30' curve is also used at New York Grand Central Terminal.
- Note 3a specifies a maximum car length of 86'-0" over the buffers and a maximum truck center spacing of 60'-0", without having horizontal clearances reduced. This provides a balanced end and mid-ordinate overhang for the Amfleet/Metroliner equipment, which is 10'-6" wide. Note 3a also applies to the Superliner Construction Outline.

- The controlling horizontal and vertical restriction is at New York's Penn Station. The Hudson River tunnel leading into Penn Station is 11'-0" wide with bench walls located about 6'-8' above the top of rail. At times, bad crosslevel in the tunnels cause the Metroliner equipment to come in contact with the bench walls.

- High-level station platforms along the Northeast Corridor are located 5'-7" from the centerline of track and 4'-0" above the top of rail. These platforms locations create about a 4" wide gap at the floor line. Newer platforms in Washington, D.C. are being constructed a distance of 5'-5" from the centerline, narrowing the gap at floor level to 2".

- In numerous locations on the Northeast Corridor, physical clearance restrictions are being removed or minimized wherever possible. In Washington, D.C., station roof canopies located at between 13'-6" and 14'-0" above top of rail, and between 4'-10" and 5'-0" from the centerline of track, are being cut back to increase clearances in that "corner area". At Penn Station in New York, signals in that same "corner area" are being relocated as time will allow.

- AREA's Place C, Equipment Diagram for Limited Interchange Service, is being used by most car manufacturers. However, Kawasaki is building new bi-level cars for the Long Island Railroad that are only 14'-6" high.

- In Chicago, commuter rail cars accessing Union Station have "up-stops" on their suspensions to prevent them from exceeding the height limitation of 16'-2".

cc: EEG
JCR
V.Patil

Parsons
Brinckerhoff

Memorandum

TO: FILE

FROM: Mike Gillam CMG

SUBJECT: TELEPHONE CONVERSATION WITH MIKE TROSINO (202) 906-2617

DATE: May 1, 1992

On this date, I talked with Mike Trosino, Senior Engineer of Clearances and Tests for Amtrak. The subject of the conversation was to understand why Amtrak's Amfleet rail vehicle did not meet the requirements of the Composite U. S. Summary Clearance Diagram (see attached figure).

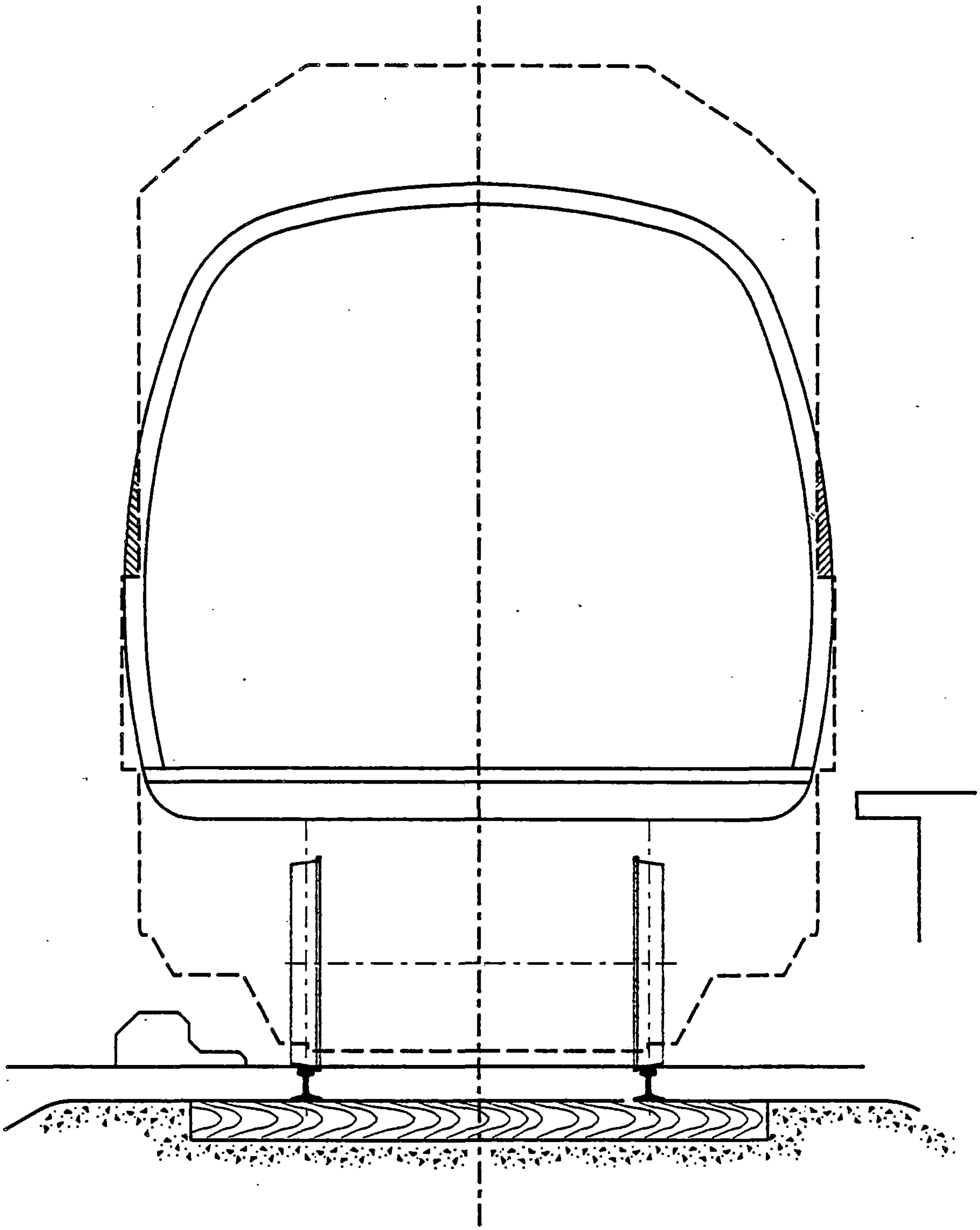
Mike noted the maximum vehicle width was in conflict from 2.18 meters (7'-2") above top of rail (TOR) to 3.66 meters (12'-0") above TOR. The original railroad cars were only allowed to be 3.05 meters (10'-0") wide, however, allowances for grab irons and other paraphernalia around door locations was added at a later time, creating the maximum width of 3.20 meters (10'-6") at a height of between 1.32 meters (4'-4") and 2.18 meters (7'-2") above TOR. He said the original Metroliners were allowed to be 3.20 meters (10'-6") all the way up and this clearance diagram violation set a precedent that continues today.

New Amfleet III Horizon rail vehicles constructed by Bombardier out of extruded aluminum have a constant width of 3.20 meters (10'-6") from 1.32 meters (4'-4") to 3.66 meters (12'-0") above TOR, and operate in New York's Penn Station. However, these cars are considered to be relatively inexpensive and from time to time hit obstructions. A program of removing these obstructions (e.g. signals, signage, light fixtures, etc.) is underway.

Mike also said the Superline Construction Outline has been revised, and he will send a copy of the revised outline as soon as possible.

MG/bd

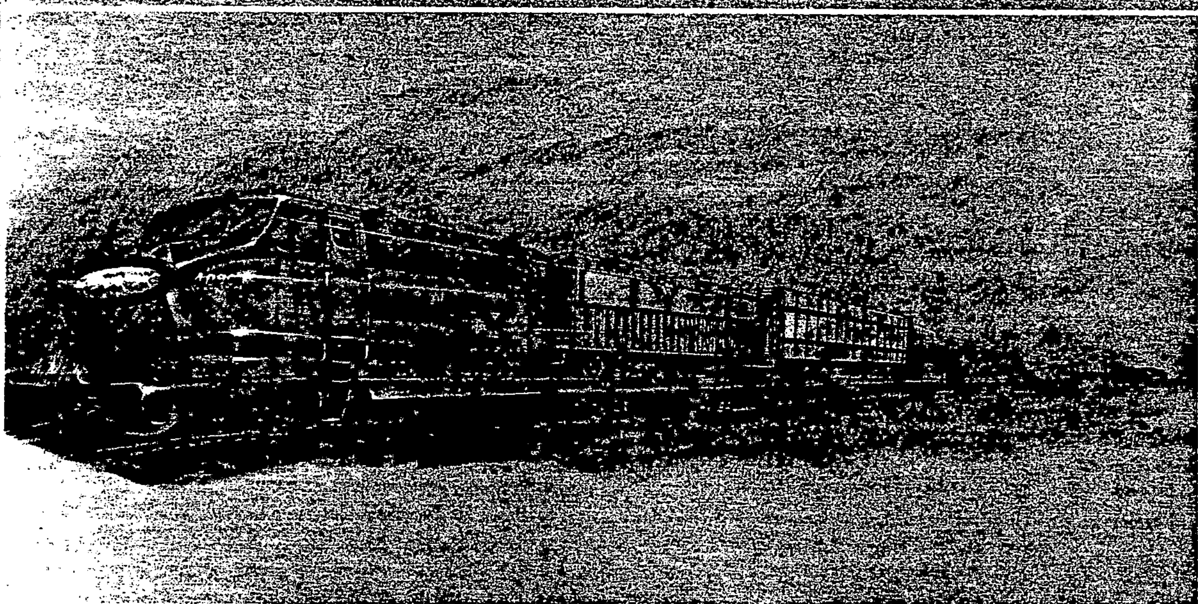
cc: EEG
JCR
VP



Amfleet at Grade

HIGH PERFORMANCE PIGGYBACK

THE IRON HIGHWAY



❖ORIGIN

In 1984 New York Air Brake Company responded to an AAR request with a proposal for a High Productivity Integral Train with a novel design called the "Iron Highway," so named because the system is intended to offer the transportation customer a cost effective and service equivalent alternative to the concrete highway. The concept, shown in *Figure 1* and *Figure 2*, has been developed through design and initial prototyping by NYAB.

Envisioned is a system designed to haul highway trailers of any length and type at lower over-the-road cost than conventional piggyback. At the same time the cost and complexity of terminals would be reduced and terminal operations sped up. The train includes a number of novel concepts intended to reduce weight, fuel consumption, equipment cost, and damage to load and equipment, along with operating expense and loading/unloading time and cost. At the same time, hitch utilization and performance on the rails would be improved in both over-the-road and train yard operations.

❖THE SYSTEM

The train does not use locomotives and cars but is made up of self-powered "elements" about 1,000 feet long. Elements may be coupled and operated in MU to form trains.

Each element is a continuous platform articulated at 28 feet with a control cab at each end. Trailers may be carried bridging the joints; length of the element can be increased for a particular service by adding 28 foot platforms. This is a simple repair track operation, but not one intended to be performed day to day.

Traction is provided by three phase AC power generated in the control cabs and fed to electric motors which drive the first and last five load bearing axles under the platform. Braking is automatic air, and both power and braking are under computer control.

Decks of the short platform segments are each equipped with a pull-up hitch which is arranged to be easily positioned at any point along the deck by the loading tractor. Hitch spacing, then, always fits the individual length of each trailer, resulting in both efficient use of deck space and improved aerodynamics.

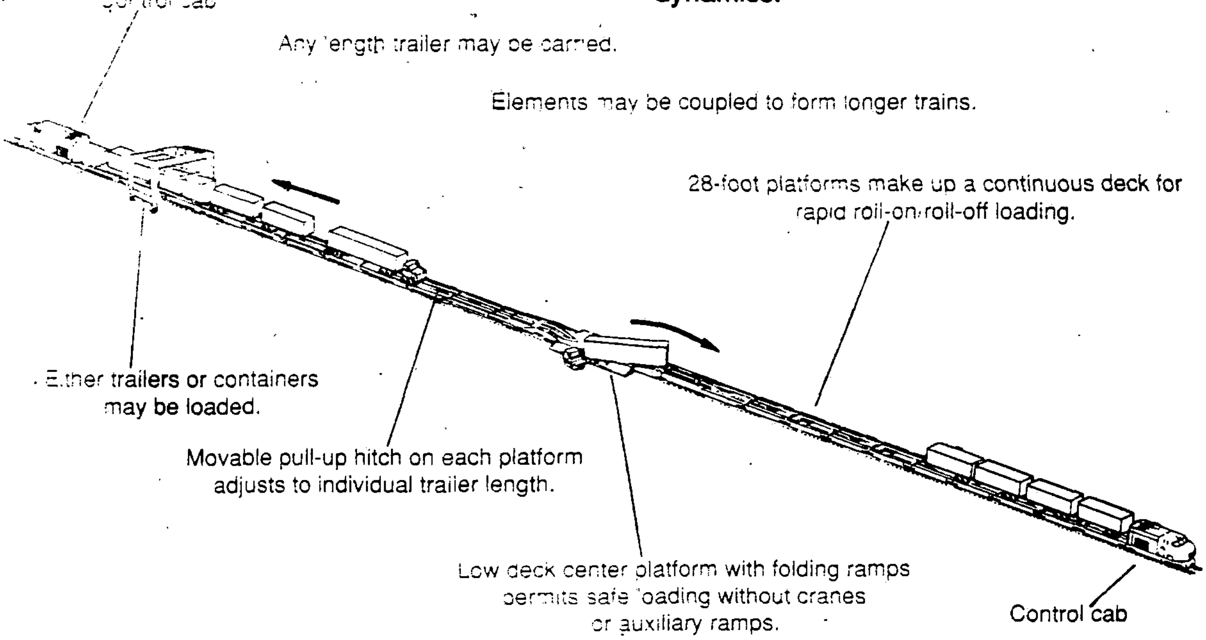
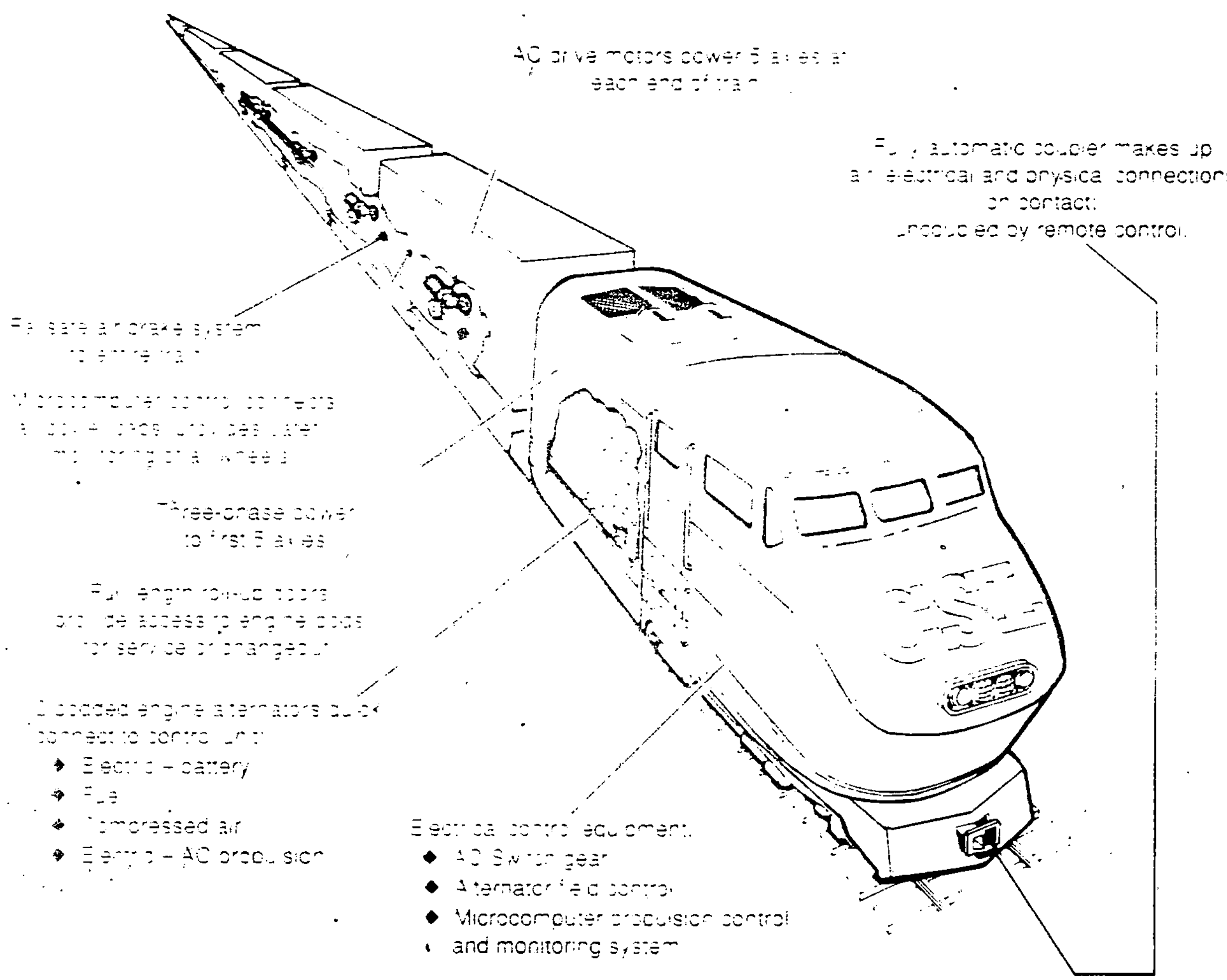


FIGURE 1 The Iron Highway Element

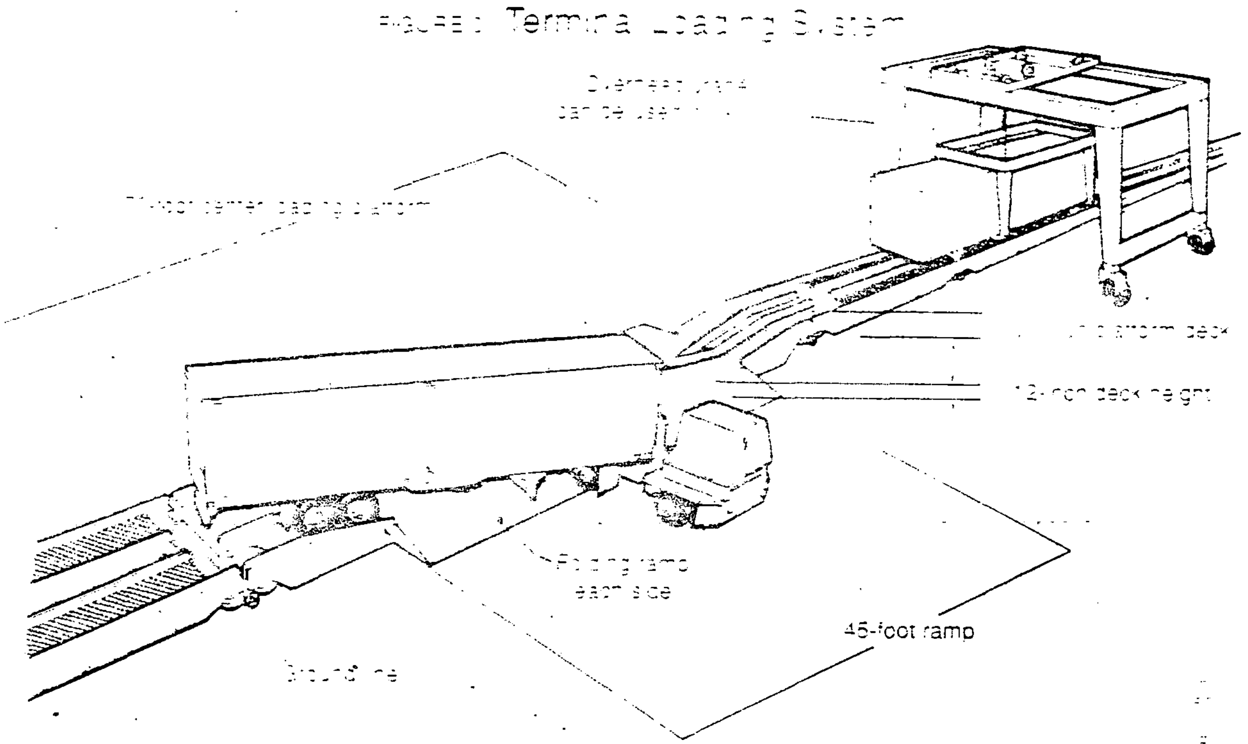
FIGURE 3 Iron Highway Element Features



ADVANTAGES

The Iron Highway system can provide the advantages listed below:

1. Better market potential because of elimination of normal piggyback trailer size/strength restrictions, better ride quality, potentially improved turnaround time and a simple low cost terminal.
2. Decreased fuel consumption both because of lighter weight and the unique "low drag" truck.
3. Lowered maintenance cost through use of high production lightweight engines and power transmission equipment; continuous systems monitoring; and quick change engines and major components which keep the train in service while components are repaired.
4. Increased opportunity for labor savings through automation of terminal inspection, train makeup or break-up and of train operation itself.
5. Decreased damage/increased customer satisfaction through use of good riding suspension and elimination of shocks due to coupling and slack action.
6. Decreased terminal cost by elimination of the need for cranes or loading ramps, and reduction of site preparation requirements.



TERMINAL

While the movable pull-up hitches can be manually positioned and conventional lift-on/lift-off loading can be used, a cost saving roll-on/roll-off system is shown in *Figure 3.* This system uses hostler tractors and the novel, movable "pull-up" hitch to provide center-of-train loading of trailers. Two hostler tractors can work on an element at the same time, and the distance each must travel is cut in half compared to conventional circus load practice. Since no loading crane or trackside preparation (other than paving level to the rail for 100 feet or so) is needed, terminals can be established quickly at required locations with very little cost.

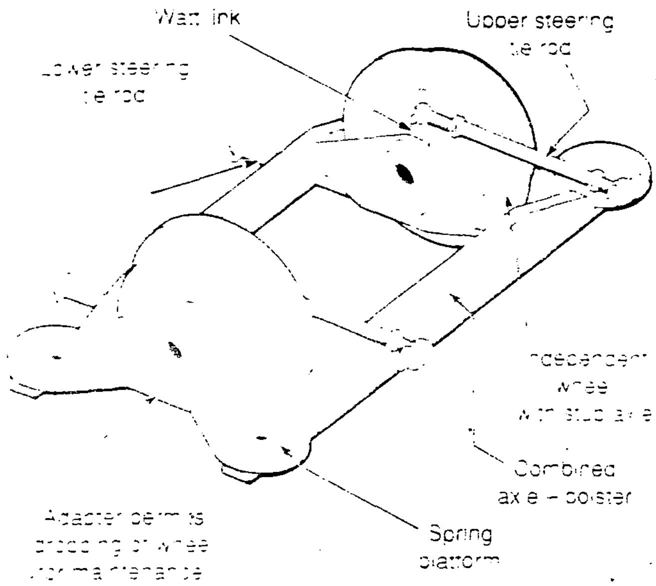
TRAIN MAKEUP

Elements are equipped with fully automatic "rapid transit style" couplers, as shown in *Figure 7,* which permit individual elements to be quickly assembled into trains without an attendant to couple hose, position knuckles or perform any of the time consuming manual chores normally associated with the coupling of cars. These couplers also connect a single wire MU control so power and braking of the train can be controlled (through microcomputers located in each control cab) from a single location. Failsafe operation is assured through the use of a conventional, pneumatic brake operable either by the microcomputer or in an override mode by manual or automatic safety devices.

TRUCK AND SUSPENSION

A novel, axleless truck is proposed which will reduce drag by as much as 30%, while at the same time reducing dead weight. The truck is steered, to reduce curve forces, and includes a soft air spring suspension to reduce loss and damage. All of these features reduce fuel consumption as well as track and equipment wear.

FIGURE 4: Suspension Unit
(Identical powered and non powered)



The truck is shown in *Figure 4* and includes a frame each end of which encloses a wheel and a pair of springs. The springs support the articulated carbodies and the wheel is carried on a stub axle having two standard railway bearings, one inside and one outside, or a total of four bearings for each two wheeled truck. Also carried on the inner bearing housing is the steering linkage. The steering feature and free wheels reduce friction losses dramatically as compared with a standard truck. Room between the hollow stub axles is reserved for a differential gearbox which is applied on powered trucks only, as shown in *Figure 5*, thus providing a common truck at all locations.

MAINTENANCE and INSPECTION

Considerable effort was placed on designing for reduced maintenance cost and down time. Critical parts of the train (wheels, bearings, brakes, engines, etc.) are designed for quick changeout and are continuously monitored by the computer-based control system so that impending problems are reported to the controlling location in their early stages and major breakdowns are avoided.

This same system also provides continuous inspection of brake and bearing status, thus eliminating the delay associated with initial terminal brake inspection while increasing safety.

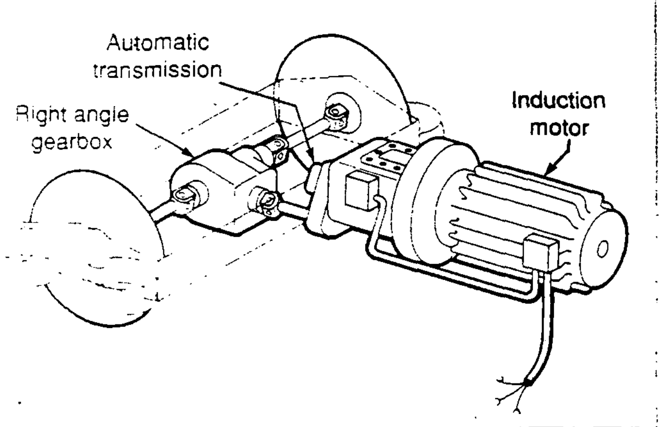
AUTOMATIC COUPLING

At each end of an Iron Highway element is a special fully automatic transit type coupler shown in *Figure 7*. It will couple two or more elements together to form higher capacity trains operable from any cab just as individual diesel electric locomotive units may be coupled and operated today. The special coupler makes up the physical connection, the air pipes, and the single wire computer communication and control line. This coupling is accomplished without a man on the ground thus improving both the speed and safety of the operation.

Design of the power and control unit nose can include a special coupler for dual mode trailers such as RoadRailer®. Efficient use of this specialized "retail" trailer is thus permitted as well as the "wholesale" delivery of standard highway trailers.

A knuckle coupler adapter and air hose, carried in the nose compartment of each power and control unit, can be installed in the special coupler by one man without tools. This permits an element to move or be moved by conventional railroad equipment if required. Such coupling requires a man on the ground to connect the air hose and line up the conventional drawbar.

FIGURE 5: Propulsion Power Train



❖PROPULSION

Propulsion for the train will come from a pair of lightweight, high speed, "truck-type" diesel engines in each control cab. Each engine is mounted in a removable pod along with its alternator, radiator, and other accessories. When maintenance of an engine or auxiliaries is required, the pod is quickly removed and replaced with a reconditioned one, and the train continued in service, as shown in *Figure 6.*

The power generated in the pods is fed to commercial induction motors which in turn drive the axles through automatic transmissions as shown in *Figure 5.* Transmission shifting is synchronized by the control microcomputer.

FIGURE 6: Podded Engine-Alternator

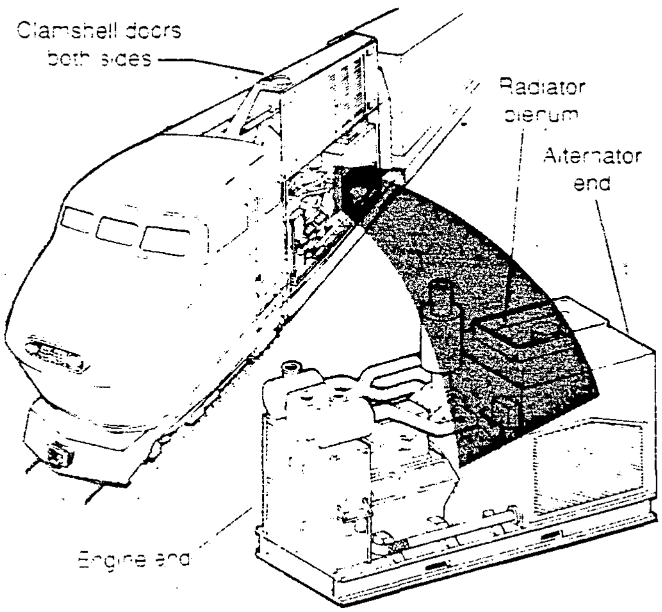
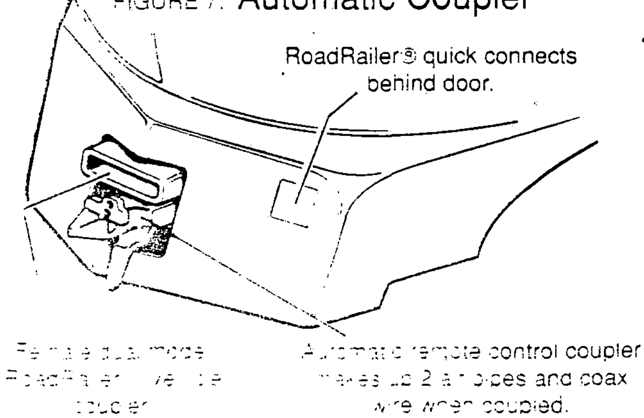


FIGURE 7: Automatic Coupler



❖TECHNICAL DEVELOPMENT

The Association of American Railroads' Technical Evaluation Committee completed its study of the twenty trailer capacity version of the train and its basic concepts prior to completion of detailed design; this evaluation helped guide the design effort. Further evaluation by individual railroad customers and the evolution of the detail design process produced significant changes from the train finally reviewed by the formal AAR committee.

One change was the use of a lightweight steel carbody frame instead of the aluminum originally proposed. A second important change was the side loading ramp system shown in *Figure 3.* This system eliminates nearly all terminal preparation and loading equipment.

Another significant change was the design of a container loading system which is permanently carried on the cars and permits a rapid one-man changeover from trailer to container carrying capability.

Additionally, a thorough evaluation of the proposed suspension system was performed by a competent consultant firm which verified the AAR's predicted excellent ride quality and provided additional data on derailment security. A prototype three-platform test car was then built and tested at the AAR test center in Pueblo, Colorado.

The performance improvements possible when the complete train is built are listed in Table I.

❖THE FUTURE

After receiving the AAR evaluation, work was concentrated on the incomplete areas of design, including wheel size, and braking problems which the AAR pointed out. Additionally, the loading system underwent considerable study and revision as did the carbody structure. A development partner, CSX-Sealand Intermodal, agreed to participate in production of a prototype in a two-year three-phase development plan; Phase I of the plan is now complete.

In Phase I, two complete trucks and three platforms were built and the suspension was tested at the AAR Pueblo Test Center at speeds of over 80 mph. At the same time a full size concrete model of the train deck, loading ramp and sliding pull-up hitch was built at the NYAB plant in Watertown, New York, and used to determine the best methods of actually loading trailers of different size. Using this model, it was determined that: (a) the loading method is practical; (b) 48 foot vans could be loaded and tied down by one man in under 5 minutes; (c) unloading time was under 3 minutes; and (d) a final configuration for both the center loading car and the hitch equipment was determined. Testing on this rig continues.

Phase II of the test program is now beginning and will produce a partial element consisting of one power and control unit, four load platforms and one center ramp platform. The novel propulsion and control system, and the other unique features will be tested under actual conditions prior to construction of a full prototype train. This partial element will be run for enough miles at Pueblo to provide assurance that all parts of the design are adequate to meet the stresses of daily living in the railroad environment.

Phase III will utilize the equipment produced for Phase II and will provide the remaining platforms and power units to produce one complete element. Naturally, any design corrections found necessary in Phase II will be incorporated in the Phase III design. The complete train will then be checked out at Pueblo.

Once safety and reliability of the full prototype are verified, the train will be turned over to CSX for experimental service, and production can commence.

Table I: PERFORMANCE ENHANCEMENT

Performance regime and anticipated improvement

SAFETY
Great improvement through elimination of attendant at coupling, through better tracking qualities and elimination of slack action.

DYNAMICS
Excellent dynamic stability is predicted in all modes.

CURVING
Reduced curve resistance and wheel/rail wear is predicted.

RIDE QUALITY
Determined excellent with air springs and a new elastomeric spring

NET-TO-TARE RATIO
60%-80% improvement over conventional; 20%-30% over spine cars.

ROLLING RESISTANCE
10%-30% lower than conventional.

AERODYNAMIC DRAG
Slightly lower than fully loaded conventional piggyback due to unbroken deck, close trailer spacing, and only one gap, regardless of number of trailers or type.

MOTIVE POWER
Engines in removable pods to reduce maintenance time and increase availability. Great savings in weight vs. conventional. AC transmission eliminates ground and flashover problems.

CONTROL SYSTEM
Continuous monitoring of performance permits maintenance scheduling for best availability and reduces initial terminal inspection time. MU control of traction and brakes from single handle.

BRAKING
Conventional brake pipe guarantees safety and simplicity. Retarder optional to minimize brake shoe consumption. Variable load braking permits high speed with reduced stop distance to improve schedule.

IN-TRAIN FORCES
Very low; better than spine cars and comparable to dual mode trailers such as RoadRailer®.

TERMINAL OPERATIONS
Minimizes both capital investment and labor cost. Eliminates need for switch engines.

STRUCTURAL INTEGRITY
Finite element analysis shows no weak spots. Tiedown will meet AAR jacking beam requirement.

TRACK MAINTENANCE
Low tare weight, good vehicle dynamics and minimum unsprung weight will lower track maintenance.

MAINTENANCE AND REPAIR
All running maintenance and fueling will be done at loading terminal. Advance notice of component failure and quick change ability at terminal will minimize line of road failures and maximize availability.

Table 2:
IRON HIGHWAY TRAIN – SPECIFICATIONS

GENERAL ARRANGEMENT

Element length	1050 feet (but can easily be varied)
Train length, maximum	5 elements MU
cab arrangement	Bi-directional – cab at each end
Carrying capacity	20 or more highway trailers
Wheel load, maximum	30,000 lbs.
Final drive	First and last 5 loaded trucks
Deck height	31 inches, min 34"
Couplers, outer ends only	Fully automatic air and electric
Coupler adapters	Loose, one in each cab
Braking rate	1.75 MPHPS – load compensated
Traction power	3,000 HP (four engines)
Tare weight, including power	550,000 lbs.
Fuel consumption	1.10 miles per gallon (20 avg. weight trailers, level track)

LOADING SYSTEM

Minimum time to unload 20 trailers	30 minutes (2 hostlers)
Minimum time to load 20 trailers	50 minutes (2 hostlers)
Loading labor requirement	Hostler driver only; no ground man needed
Trailer maximum length	Unrestricted
Trailer maximum weight	85,000 lbs.

POWER SPECIFICATION

Engines	Cat 3412 @ 750 HP
Alternators	Cat 1000 KN 30 20-70 HZ
Excitation	Constant 8 volts per hertz
Voltage	480 at 60 Hertz, proportional to engine speed
Governing system	Direct rack position (8 settings) with engine overspeed control
Transmission	3 phase AC with hydromatic final, computer synchronized
Drive train	(10) NYAB DT-1
Motor	300 HP-3 PH 750-3000 RPM
Automatic transmission	Detroit Diesel Allision HT 740
Dynamic brake	Optional hydraulic retarders
Reverse box	Fairfield Special
Output gearing	Fairfield 1.2:1 differential
Coupling to output	Cardan shaft and Universal joints

SUSPENSION

Lead truck – 1 each end	Barber Bettendorf swing hanger (non powered)
Load truck	2 wheel independent forced steering
Power truck	Identical with load truck – includes gearbox
Springs	Firestone air rail springs (4 per truck)
Shock absorbers	Air damping and General Kinetics hydraulic
Load path	Non-center bearing – direct transmission to side sills
Articulation	NYAB slack-free with automatic wear compensation

CONTROL SPECIFICATION

System schedule	No. 8 IT traction control
Propulsion control	Microcomputer – MU by single wire trainline and modem
Engineman's control	Single handle propulsion brake
Spring brake control	On-Off – Released by main reservoir air
Wheelslip – propulsion	Not required – inherent in design
Wheelslip – braking	None required; load proportional system
Engineman's auxiliary controls	Soft keys and display screen
Braking system	Conventional brake pipe – electrically operated by microcomputer at each cab
Loadweigh	Continuous load compensation piloted by air spring pressure
Control valve	ABE with auxiliary load compensating valve
Brake cylinder supply	Self lapping from protected supply reservoir

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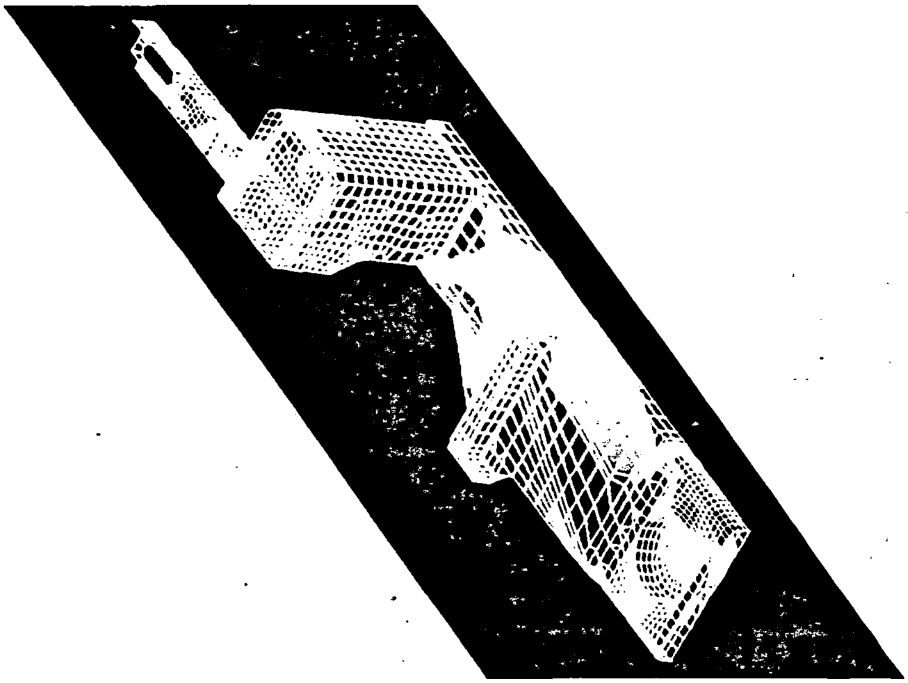

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