INTERCITY PASSENGER PARAMETRIC ANALYSIS

OVERVIEW

MAGLEV ANALYSIS

April 2, 1990

John B. Hopkins

Office of Transportation Strategic Planning and Analysis
Transportation Systems Center
Research and Special Programs Administration
U.S. Department of Transportation
Cambridge, Massachusetts 02142

FOREWORD

This document provides information intended to clarify consideration of some of the technically-based questions which arise in connection with intercity passenger transportation, and to provide insight into the characteristics and potential roles of the various modes available for this function at present and in the foreseeable future. The material presented is based upon simple analytical models applied to a wide range of parameter values; these findings can be helpful in identifying critical technical and economic questions and as a starting point for assessing potential system implementations. However, decisions concerning real intercity transportation initiatives or projects can properly be based only on detailed and rigorous examination of the specifics of construction and operating costs, potential demand, social and environmental impacts, and the overall transportation context of which the system is to be a part.

The analysis described here is the first result of an ongoing activity at the Transportation Systems Center. This document addresses overall aspects of intercity passenger transportation and examines some of the characteristics which may be expected of magnetic levitation systems. In the future, it is planned that the analysis will be extended to conventional high speed rail systems and powered lift (tiltrotor) aircraft. Comments on this work and directions in which it might usefully be extended are welcome.

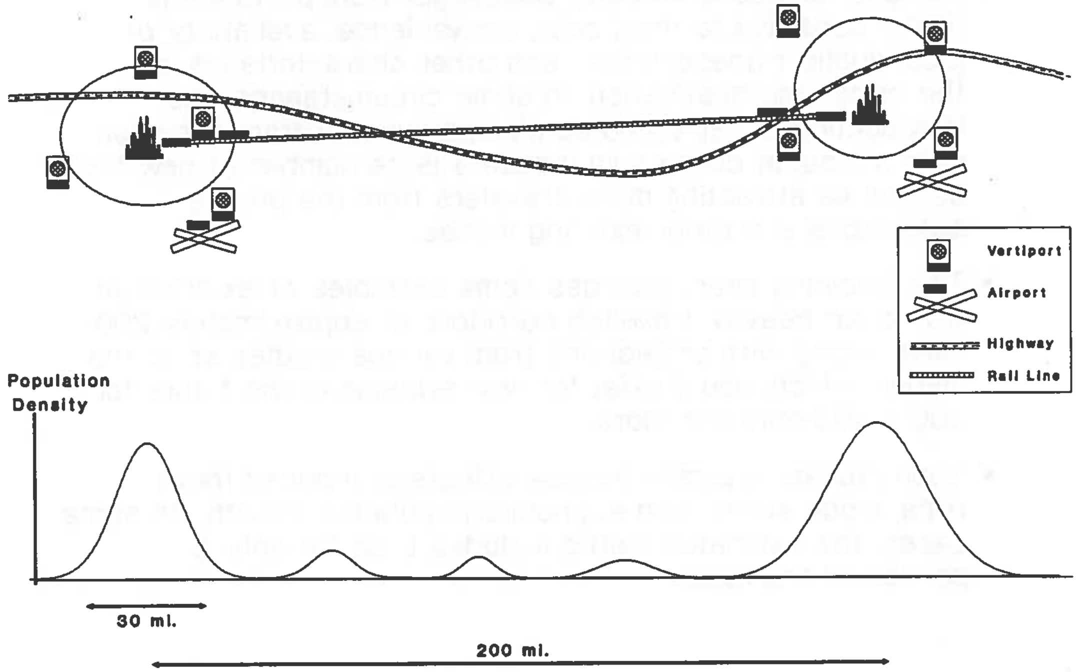
CONTENTS

INTERCITY PASSENGER TRANSPORTATION

OVERVIEW AND FRAMEWORK

INTERCITY PASSENGER PARAMETRIC ANALYSIS

INTERCITY TRANSPORTATION FRAMEWORK



INTERCITY PASSENGER PARAMETRIC ANALYSIS

INTERCITY TRANSPORTATION FRAMEWORK

- POPULATION IS CLUSTERED IN LARGE URBAN COMPLEXES; TYPICALLY LOW POPULATION DENSITY IN BETWEEN
- INTERCITY TRANSPORTATION IS BETWEEN REGIONS (30 - 60 MILES IN DIAMETER), NOT "CITY CENTERS"
- TRANSPORTATION NEEDS DEPEND STRONGLY ON PRIMARY PURPOSES OF TRAVEL FOR SPECIFIC CORRIDOR, LOCATION OF PRINCIPAL DESTINATIONS WITHIN REGION, AND ACTUAL POPULATION DISTRIBUTION
- "INTERCITY SYSTEMS" ADDRESS ONLY LINEHAUL PORTION--VIABILITY AND VALUE DEPEND ON LOCAL (URBAN-SUBURBAN) PUBLIC TRANSPORTATION
- ABOVE 500 - 600 MILES, AIR IS TYPICALLY THE ONLY VIABLE LARGE-CAPACITY LINEHAUL SYSTEM
- BELOW 100 - 150 MILES, HIGHWAY (PRIVATE AUTO) DOMINATES

TOTAL TRAVEL TIME

- Travellers are concerned primarily with total travel time (from "portal-to-portal"), not merely the linehaul portion of the trip. The "access" portion -- from origin to beginning of linehaul, and from end of linehaul to final destination -- often differs substantially among modes and can contribute strongly to modal choice of travellers.
- The following charts indicate the type and magnitude of the impacts of access time. This analysis is based on assumed access parameters which are plausible in many cases but will often be totally inappropriate. These charts therefore do not imply any general conclusion concerning attractiveness of various modes.
- Modal choice is influenced strongly by factors other than travel time, such as cost, convenience, availability of local transportation, reliability, and comfort.

INTERCITY PASSENGER PARAMETRIC ANALYSIS

TOTAL TRAVEL TIME - ASSUMED PARAMETERS

	Access Time (min.)	Accel/Decel (min.)	Cruise Speed (MPH)
Air	60	20	550
Auto	20	0	60
Smart Auto	25	5	90
HS Rail	45	15	160
Maglev	40	10	225
Verticraft	30	10	200

Access Time - Time to travel between origin or destination and terminal or Interstate ramp

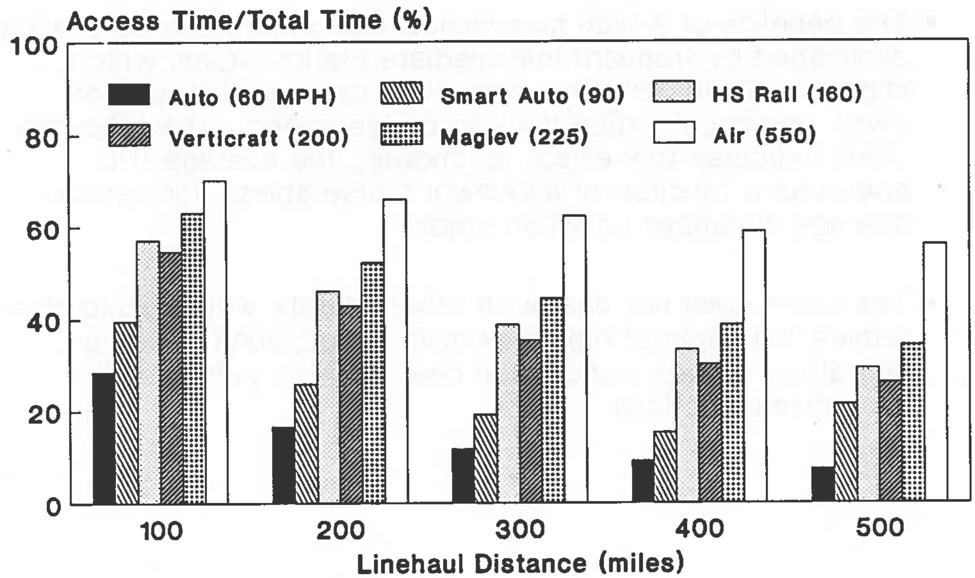
Accel/Decel - Time period at each end of linehaul portion between departure/arrival at gate/platform and attainment of cruise speed

Cruise Speed - Cruising speed as typically experienced; often less than maximum speed due to route curvature, minor slowdowns, weather, etc. (Cruise Time - Route Length / Cruise Speed)

These parameters can vary widely in specific circumstances. The values shown here are considered reasonable for generic analysis, but may not be applicable to a particular case.

INTERCITY PASSENGER PARAMETIC ANALYSIS

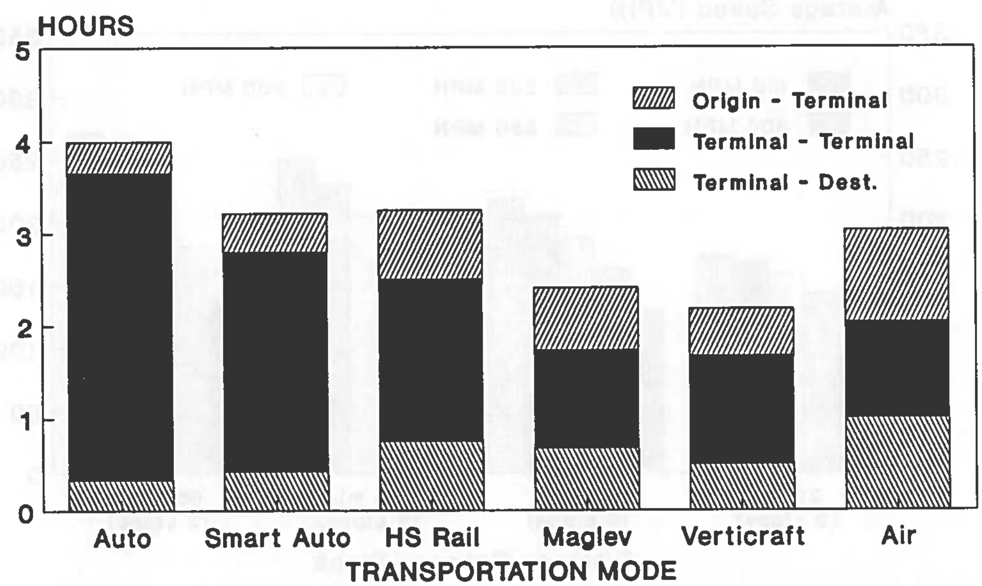
ACCESS TIME AS A PERCENTAGE OF TOTAL (PORTAL-TO-PORTAL) TRAVEL TIME



Based on specific assumed values for access to/from linehaul portion and transition to/from nominal cruise speed

INTERCITY PASSENGER PARAMETRIC ANALYSIS

DIVISION OF TIME BETWEEN ACCESS AND LINEHAUL PORTIONS OF A 200 MILE TRIP



Based on specific assumed values for access to/from linehaul portion and transition to/from nominal cruise speed

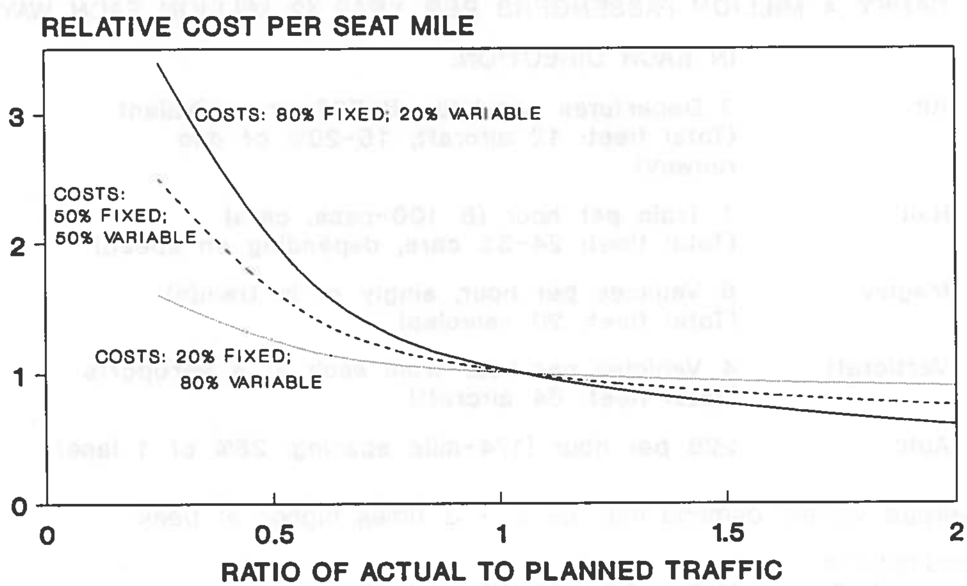
For Auto, "Terminal" is taken as interstate highway exit/entrance ramp

PERCENTAGE OF FIXED VS. VARIABLE COSTS

- Many transportation systems consist primarily of fixed plant; most of their cost lies in construction of guideway. This is true of Maglev. For other modes, such as vertical flight aircraft, most of the costs are associated with the vehicles -- which can be acquired only as warranted by traffic -- and operations. These are the "variable" costs.
- The variation of total cost per seat-mile with traffic depends strongly on the proportion of system cost which is fixed. Systems with a higher percentage of fixed costs are more sensitive to the level of traffic actually carried, compared to the value used for initial financial calculations, than are systems with predominantly variable costs.
- The following chart illustrates this effect by presenting seat-mile cost curves for three cases: 80% fixed cost (typical of Maglev); 50%, and 20%. The cost is plotted against a ratio: traffic actually obtained divided by the traffic originally anticipated. Higher-than-anticipated traffic yields substantially greater benefits (lowered operating cost) for the high-fixed-cost case, but also imposes a greater penalty than high-variable-cost if traffic is below expectations.

INTERCITY PASSENGER PARAMETRIC ANALYSIS

RELATIVE COST PER SEAT MILE AS A FUNCTION OF ACTUAL/PLANNED TRAFFIC RATIO



The indicated fixed and variable percentages are for planned traffic (i.e., actual/planned traffic = 1)

INTERCITY PASSENGER TRANSPORTATION

MAGLEV PARAMETRIC ANALYSIS

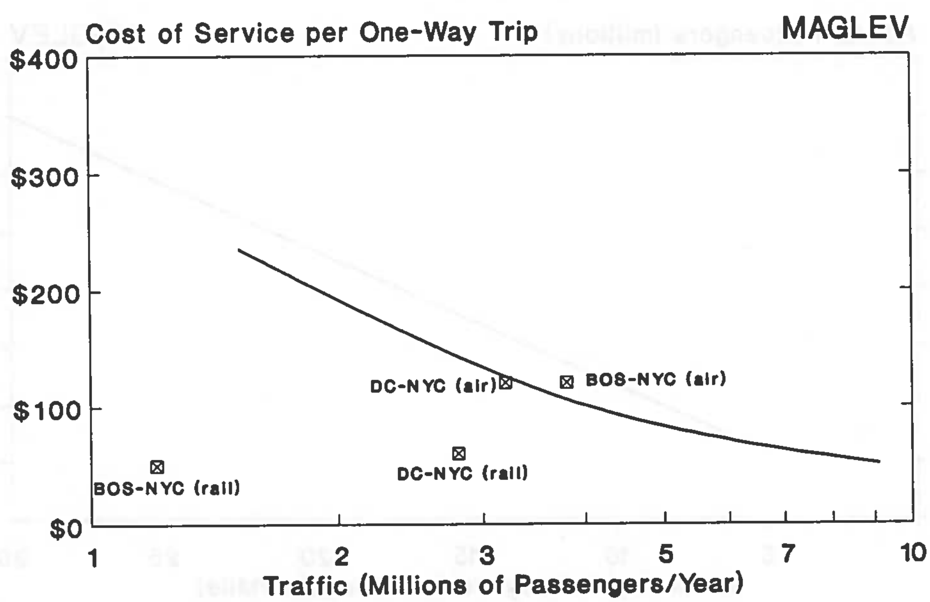
HOW MUCH WILL IT COST TO PROVIDE TRANSPORTATION USING MAGLEV?

- The cost of service per passenger carried, under the baseline assumptions, is shown in the following chart as a function of passenger traffic: number of one-way trips, for both directions. This does not include any profit margin for the owner/operator.
- Typical traffic and fare values for air and rail service between Boston and New York (BOS-NYC) and Washington and New York (DC-NYC) are shown as a way of providing approximate "calibration" points for traffic. For trips of comparable distance, the Boston - New York and New York - Washington corridors are, by a large margin, the most heavily travelled intercity routes in the U.S.
- Maglev is highly capital-intensive, so costs are quite sensitive to interest rates. The baseline value used in this analysis is 10%, as specified by the Office of Management and Budget. Since this is the real interest rate, excluding inflation, 10% may be considered by some to be excessive. Charts are included which show the sensitivity of results to the assumed interest rate.

INTERCITY PASSENGER PARAMETRIC ANALYSIS

TRIP COST VS. TRAFFIC

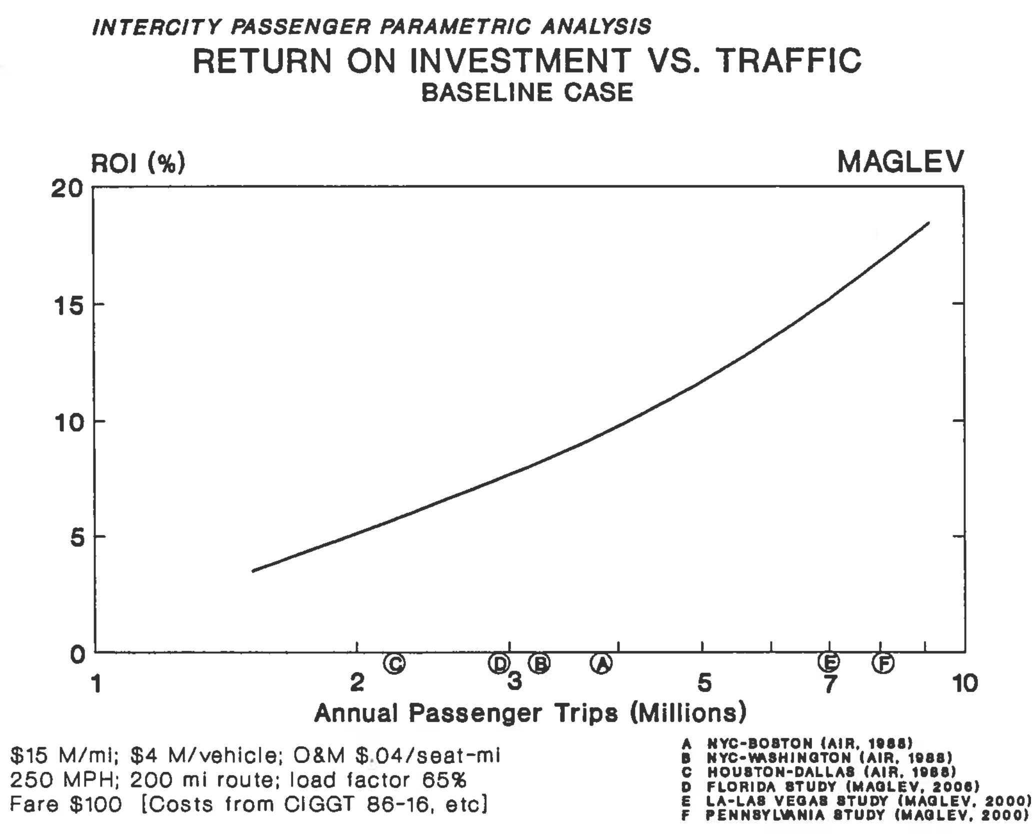
BASELINE CASE



$15 M/mi; $4 M/vehicle; O&M $.04/seat-mi
250 MPH; 200 mi. route; fare $100
Costs from CIGGT 86-16 and other studies

ERRATA

The chart at the bottom of page 15, which shows the baseline case for maglev Return on Investment, was inadvertently drawn for a case other than baseline, and shows incorrect values. The correct version is given below.



WHAT RETURN ON INVESTMENT CAN BE EXPECTED?

- Return on investment (ROI) is the interest (or "discount") rate for which the present value of the future stream of system expenses equals the present value of the future revenue stream. The chart below shows the Maglev ROI, under the baseline assumptions, as a function of traffic.

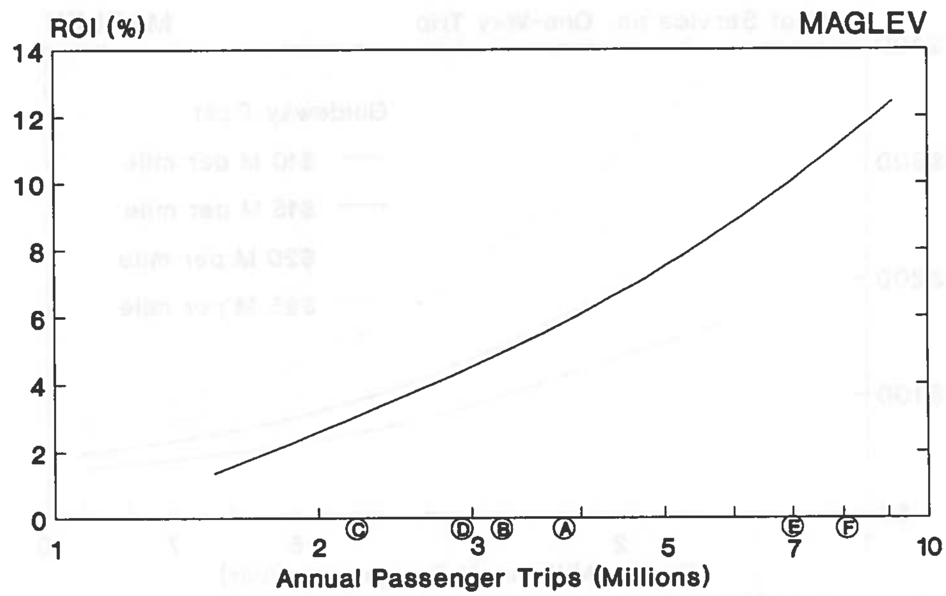
- ROI as shown here is in terms of the "real" interest rate – the difference between the nominal interest rate and inflation. The nominal ROI would be the values shown in the charts plus the inflation rate.

- Traffic now experienced and projected for various corridors is shown in order to provide "calibration" points for the required traffic values.

INTERCITY PASSENGER PARAMETRIC ANALYSIS

RETURN ON INVESTMENT VS. TRAFFIC

BASELINE CASE



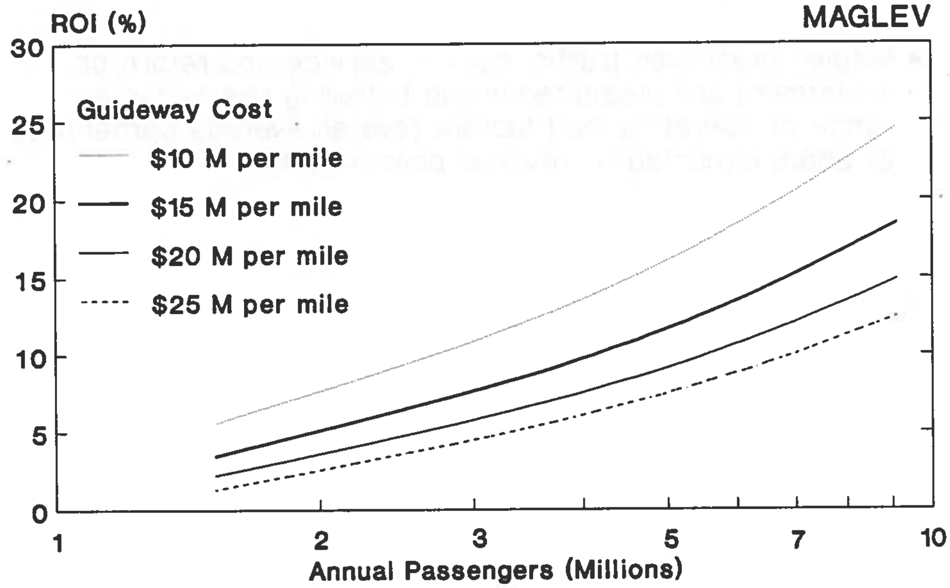
$15 M/mi; $4 M/vehicle; O&M $.04/seat-mi
250 MPH; 200 mi route; load factor 65%
Fare $100 [Costs from CIGGT 86-16, etc]

A NYC-BOSTON (AIR, 1988)
B NYC-WASHINGTON (AIR, 1988)
C HOUSTON-DALLAS (AIR, 1988)
D FLORIDA STUDY (MAGLEV, 2006)
E LA-LAS VEGAS STUDY (MAGLEV, 2000)
F PENNSYLVANIA STUDY (MAGLEV, 2000)

INTERCITY PASSENGER PARAMETRIC ANALYSIS

RETURN ON INVESTMENT VS. TRAFFIC

FOR VARIOUS GUIDEWAY COSTS

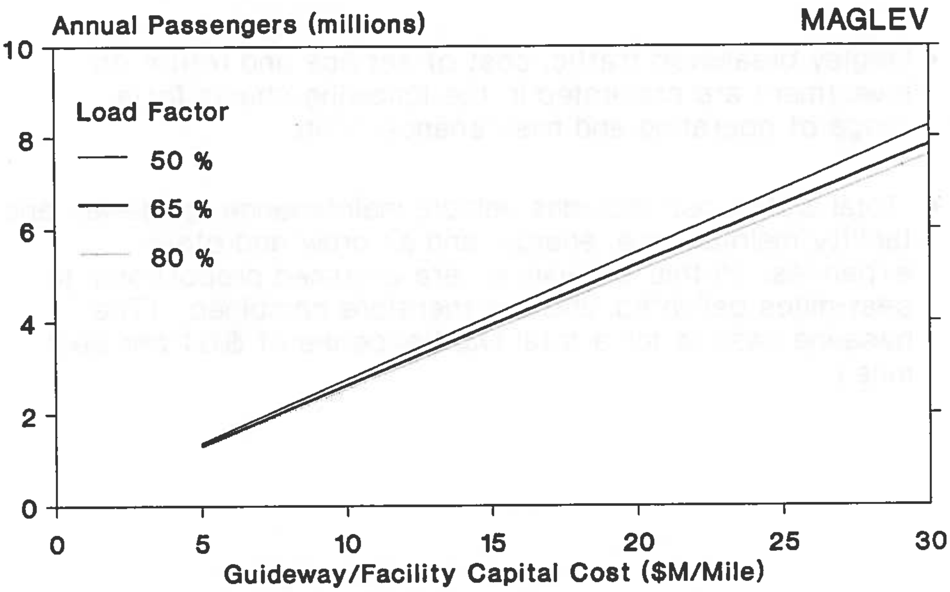


$4 M/vehicle; O&M $.04/seat-mi;fare $100
250 MPH; 200 mi route; load factor 65%
Costs from CIGGT 86-16 and other studies

INTERCITY PASSENGER PARAMETRIC ANALYSIS

BREAKEVEN TRAFFIC VS. GUIDEWAY COST

FOR VARIOUS LOAD FACTORS

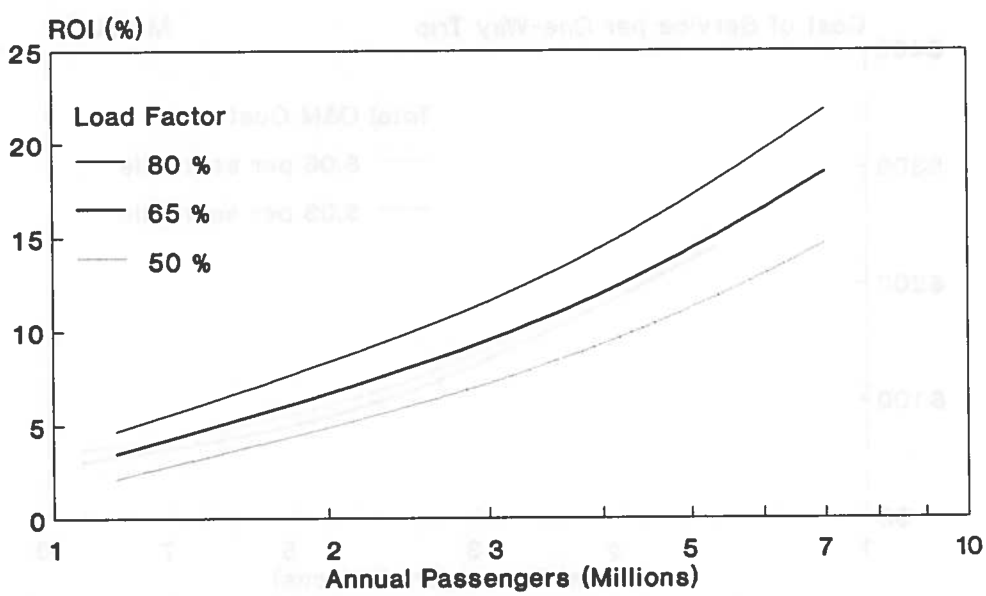


$4 M/vehicle; O&M $.04/seat-mi;fare $100
250 MPH; 200 mi. route; 10% int. rate
Costs from CIGGT 86-16 and other studies

INTERCITY PASSENGER PARAMETRIC ANALYSIS

RETURN ON INVESTMENT VS. TRAFFIC

FOR VARIOUS LOAD FACTORS

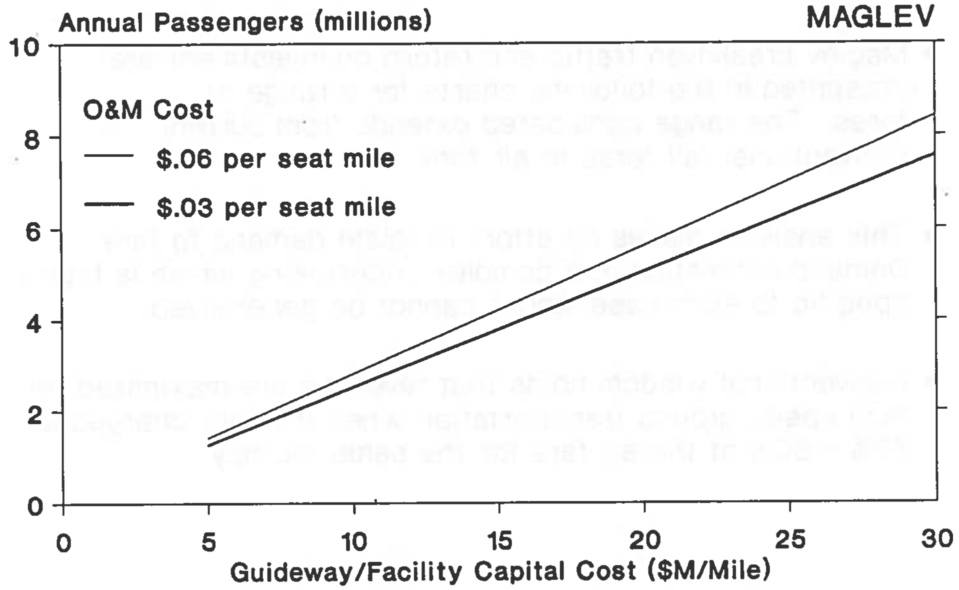


$15 M/mi; $4M/vehicle; O&M $.04/seat-mi.
250 MPH; 200 mile route; fare $100
Costs from CIGGT 86-16 and other studies

INTERCITY PASSENGER PARAMETRIC ANALYSIS

BREAKEVEN TRAFFIC VS. GUIDEWAY COST

FOR VARIOUS LEVELS OF O&M COST

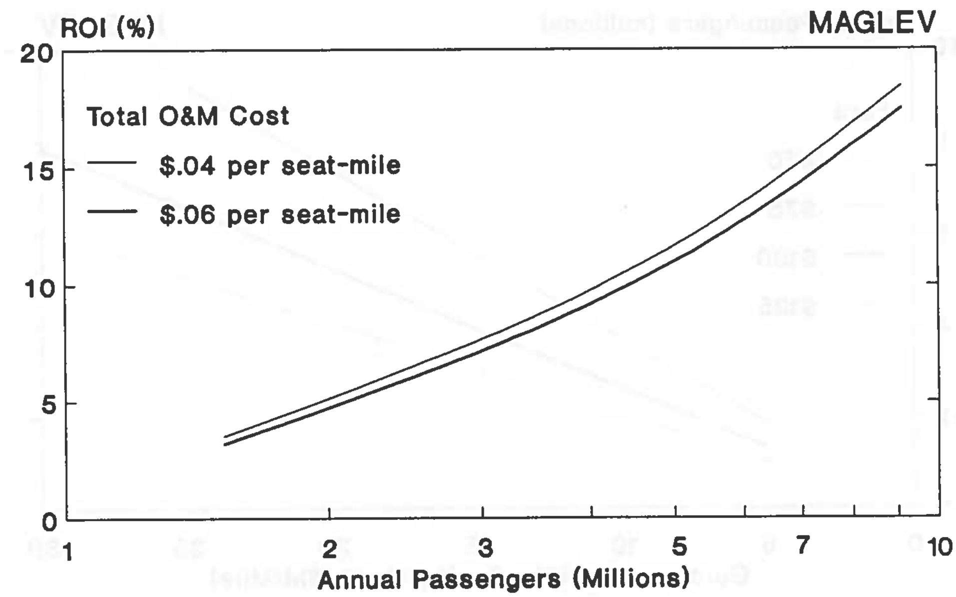


$4 M/vehicle; fare $100; int. rate 10%
250 MPH; 200 mi. route; load factor 65%
Costs from CIGGT 86-16 and other studies

INTERCITY PASSENGER PARAMETRIC ANALYSIS

RETURN ON INVESTMENT VS. TRAFFIC

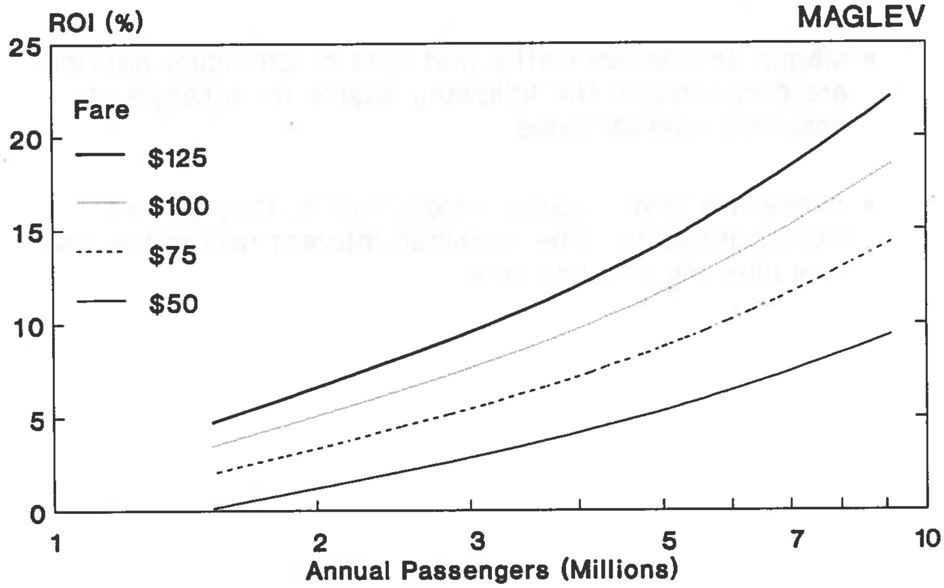
FOR VARIOUS LEVELS OF O&M COST



$15 M/mi; $4M/vehicle; fare $100
250 MPH; 200 mi. route; load factor 65%
Costs from CIGGT 86-16 and other studies

INTERCITY PASSENGER PARAMETRIC ANALYSIS

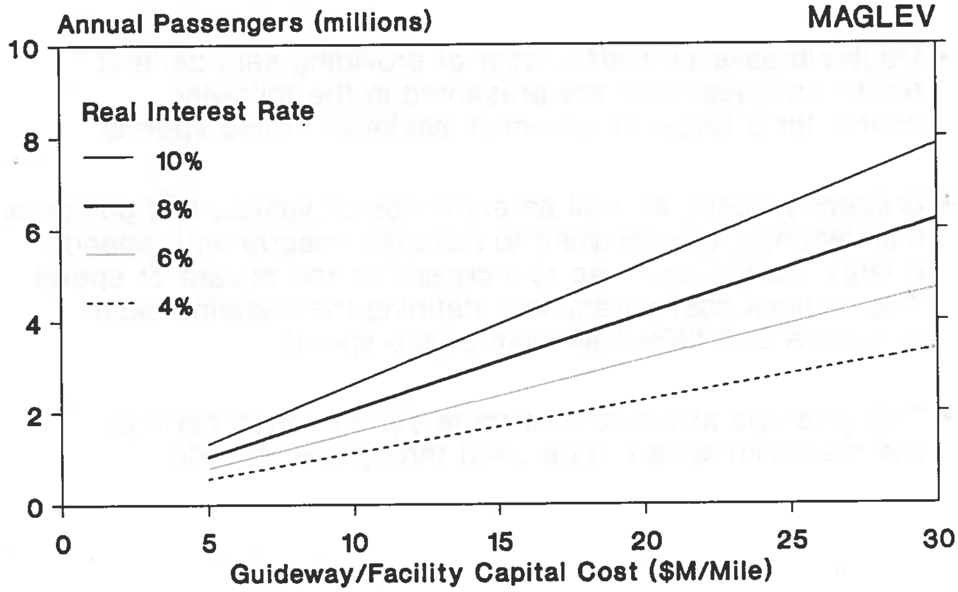
RETURN ON INVESTMENT VS. TRAFFIC
FOR VARIOUS FARES



$15 M/mi; $4M/vehicle; O&M $.04/seat-mi.
250 MPH; 200 mi route; Load Factor 65%
Costs from CIGGT 86-16 and other studies

INTERCITY PASSENGER PARAMETRIC ANALYSIS

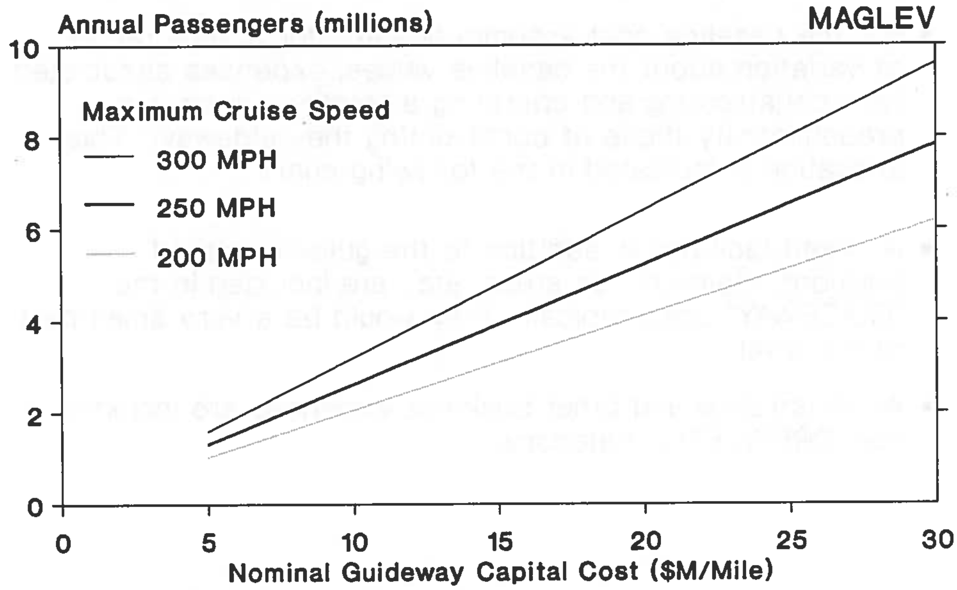
BREAKEVEN TRAFFIC VS. GUIDEWAY COST
FOR VARIOUS REAL INTEREST RATES



$4 M/vehicle;O&M $.04/seat-mi;fare $100
250 MPH; 200 mi. route; load factor 65%
Interest rate: real (excludes inflation)

INTERCITY PASSENGER PARAMETRIC ANALYSIS

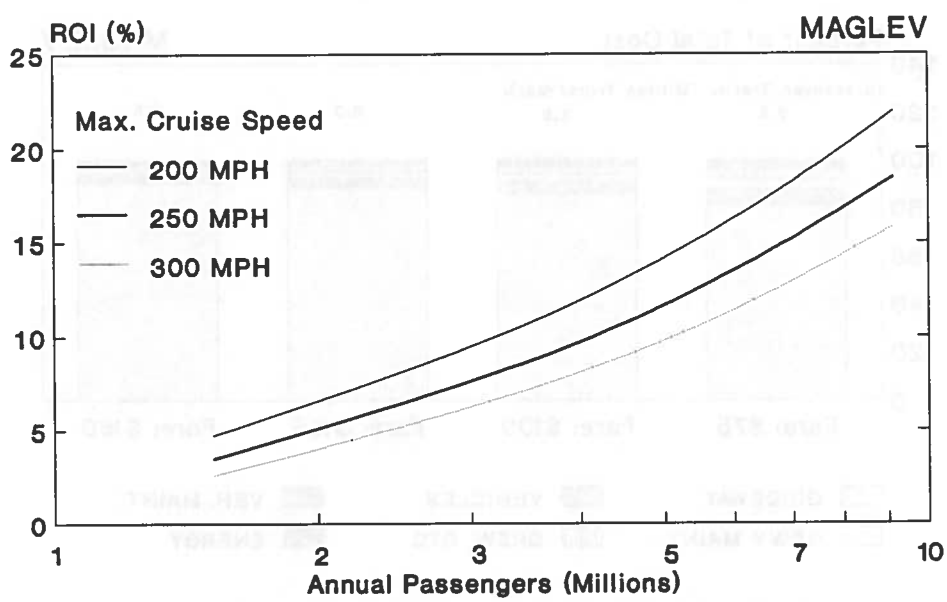
BREAKEVEN TRAFFIC VS. GUIDEWAY COST
FOR VARIOUS MAXIMUM CRUISE SPEEDS



$4 M/vehicle; Fare $100;O&M $.04/seat-mi
Guideway and maint. costs assumed linear
with speed; nominal values are at 250MPH

INTERCITY PASSENGER PARAMETRIC ANALYSIS

RETURN ON INVESTMENT VS. TRAFFIC
FOR VARIOUS MAXIMUM CRUISE SPEEDS



$15 M/mi; $4M/vehicle; O&M $.04/seat-mi.
Guideway and maintenance costs linear
with speed; nominal values at 250 MPH

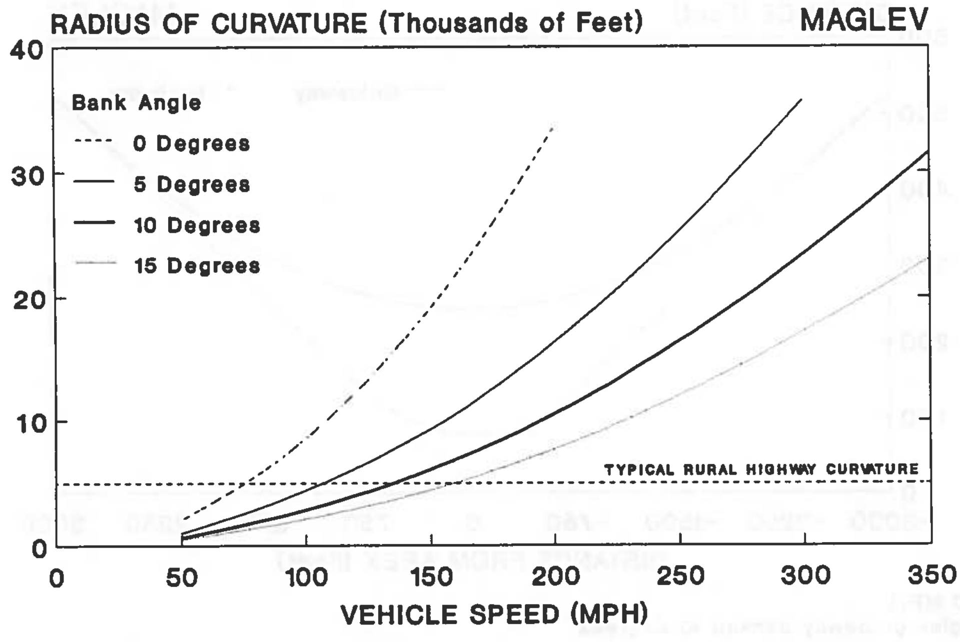
WHAT CONSTRAINTS ARE ASSOCIATED WITH ROUTE CURVATURE?

- At very high speeds, even gentle turns in the route require some combination of reduced speed and banking to assure comfort of passengers. A bank angle, or superelevation, of 10 degrees is generally taken as a practical maximum. It is widely accepted that passengers will accept up to approximately .08 G lateral acceleration, which has the effect of an additional 5 degrees of banking. The chart below shows the required radius of curvature as a function of speed for these values (10 degrees banking, .08 G).

- Interstate highways are frequently suggested as possible Maglev routes. Radius of curvature for these roads is typically 4000 - 6000 feet, but with banking can be as low as 2000 feet for a 70 MPH design speed.

INTERCITY PASSENGER PARAMETRIC ANALYSIS

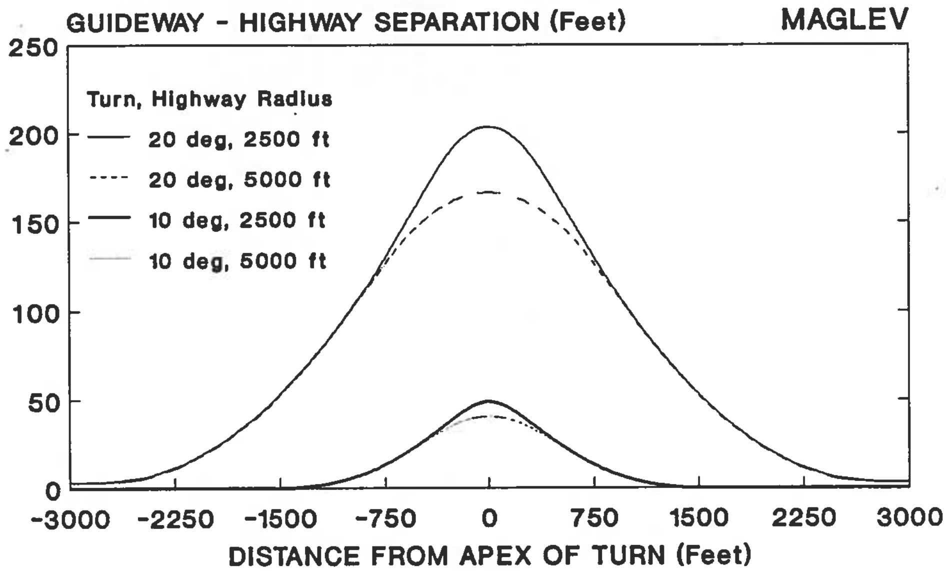
REQUIRED RADIUS OF CURVATURE AS A FUNCTION OF SPEED



Unbalanced lateral acceleration: .08 G

INTERCITY PASSENGER PARAMETRIC ANALYSIS

DEVIATION OF GUIDEWAY FROM HIGHWAY AS A FUNCTION OF TOTAL ANGLE AND CURVATURE

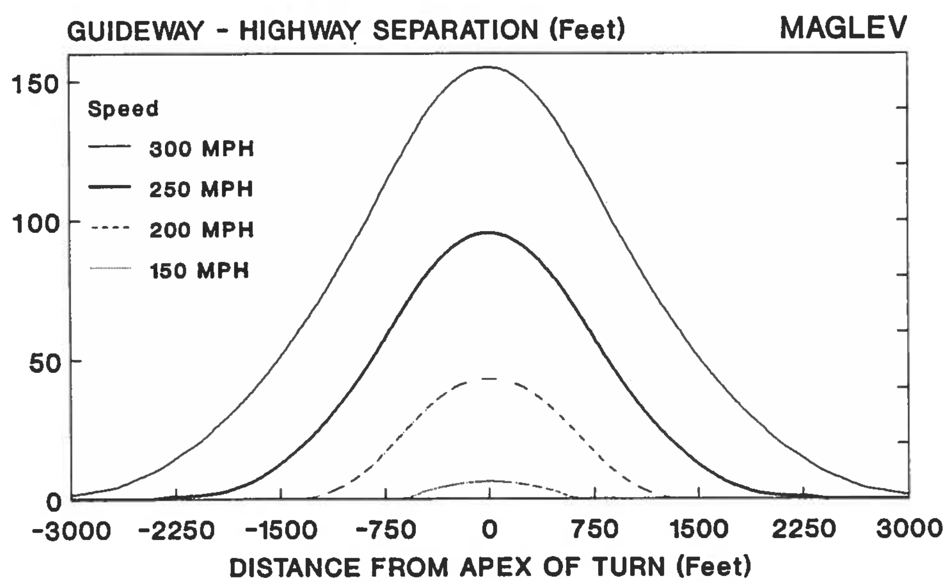


250 MPH
Maglev guideway banked 10 degrees

Vertical scale greatly exagerated

INTERCITY PASSENGER PARAMETRIC ANALYSIS

DEVIATION OF GUIDEWAY FROM HIGHWAY AS A FUNCTION OF VEHICLE SPEED



Total turn 15%; 5000 ft. highway radius
Maglev guideway banked 10 degrees

Vertical scale greatly exagerated