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High-Speed Ground Transportation Systems Engineering Study

TRACKED AIR CUSHION VEHICLE SYSTEMS

Prepared for the U.S. DEPARTMENT OF TRANSPORTATION
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16. Abstract

The tracked air cushion vehicle is one of several advanced ground transportation systems being studied by TRW Systems Group for the Department of Transportation as a possible means of providing safe, high-speed, high-capacity transportation along densely populated areas such as the Northeast Corridor. Based on requirements and constraints chosen for an operational system, subsystem alternatives are evaluated and the selected subsystems are synthesized into a TACV system. Cost and performance are estimated over a range of parameters, such as design cruise speed (150 to 350 mph) and vehicle capacity (50 to 150 passengers per vehicle). The configuration defined consists of trainable, electrically powered TACV's which collect power from trackside power rails mounted on the side of a channel guideway. Propulsion is by linear induction motors with variable frequency speed control. Control of the vehicles, singly or in trains, is automated and centralized. The vehicles are supported on and guided by peripheral jet air cushions with high pressure air provided by electrically driven axial flow compressors.

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ABSTRACT

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CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

FOREWORD

This report is one of a series prepared under Contract C-353-66 (Neg) by TRW Systems Group of TRW Inc. for the Office of High Speed Ground Transportation (OHSGT) of the Federal Railway Administration, U.S. Department of Transportation.

One purpose of the reports is to provide system definitions for the Northeast Corridor (NEC) Transportation Project. These definitions are descriptions of representative alternative high-speed ground transportation systems that can be engineered from current technology for service in the late 1970s or early 1980s. A second purpose is to indicate areas in which development work is necessary to realize the defined systems.

The system definitions contain general design concepts and performance characteristics. Conceptual design studies are carried to the point that feasibility is clear within today's technology or the development needed can be delineated, and that performance can be computed and cost estimation data generated. Preliminary or detailed design as needed to satisfy these purposes is included. It is to be expected that some alternates to the defined subsystems will be "designer's choices". Insofar as feasible, the study data are parametrically treated. Tradeoffs between parameters, and variations about the defined systems are demonstrated.

We have attempted to prepare the report for a general readership rather than one that consists solely of engineers, using language and approaches, particularly in the summary sections, that are not highly technical. Refined comparisons among the candidate systems, and design and development engineering of systems chosen for service construction, will require updating of assumptions and analyses to incorporate advances in technology.

This report on TACV Systems is essentially identical to the TACV Systems Engineering Study Report (i.e. NECTP-219) issued as part of the documentation set for the Northeast Corridor Transportation Project Report of December, 1969. The primary difference involves a more detailed Implementation section in the present report.

The study reports cover efforts in 1967, 1968, and 1969. The volumes in this series are:

Title

High Speed Rail Systems

Tube Vehicle Systems

Multimodal Systems

Automated Highway Systems

Tracked Air Cushion Vehicle Systems

Supporting Studies for HSGT System Reports

A listing of the contents of the Supporting Studies volume is presented in Table 1-1.

Table 1-1. Supporting Studies

Appendix Symbol	Title
A.	Feasibility of Long Rail Support System Train Cars
B.	Aerodynamics of High-Speed Ground Transportation Vehicles
C.	Parametric Representation of Gas Turbine Propulsion System Characteristics
D.	Power Distribution
E.	Sample Calculation of Weight and Volume of a Power Conditioning Unit (PCU)
F.	Electrical Braking for HSGT Systems
G.	Guideway Roughness Criteria
H.	Transition Easements Ease-6 Computer Program
I.	Three Mass Vertical Dynamic Model
J.	Four-Degree-of-Freedom Lumped Mass Model
K.	Lateral Dynamic Model
L.	Fourier Harmonic Analysis for Damped Linear Systems
M.	Effective Mass of an Improved Roadbed Above Resonance
N.	Design of Flexible Guideways for Smooth Vehicle Travel
O.	Transop Listing for TVS
P.	Battery Technology Review
Q.	A Control Law for Functional Trains
R.	The Safety of Functional Trains
S.	Performance of a Pneumatically Propelled TVS-Listing and Nomenclature

T. Modelling and Optimal Performance of Passenger Transportation Networks Operating Under Fixed-Schedule Policy

U. The Problem of Schedule Determination and Vehicle Distribution for the Dispatch Policy: Go When Full or After First Passenger Has Waited X Minutes

V. Modelling and Optimal Performance of Free-Schedule Transportation Systems

W. Quasi-Steady Gas Dynamic Computer Program Listing and Nomenclature

X. Stepped Position Electronic Escort Device (Speed) A System of Train Control

Y. Drag of Vehicles Travelling in Tubes

Z. Derivation of the Equations of Motion for Independently Rotating Wheel Systems

AA. Tube Vehicle System Safety

BB. Tube Vehicle System Safety Specification

CC. Electric Arc Power Pickup

DD. Electromagnetic Suspension

EE. RSS-2 Vehicle Stability Computer Program Listing

FF. Roadbed Model and Computer Program

GG. Dynamic Response of a Spring Mounted Guideway

HH. Guideway Construction Analysis

II. Matrix Coefficients for Rigid-Truck TVS Lateral Dynamic Models

2. INTRODUCTION

The increasing concentration of population in and adjacent to our large cities has created corridors of high population density. Typically, such corridors are several hundred miles long and 50 to 100 miles wide. Transportation between the major cities on these corridors is of a linear-flow type, as contrasted with the area flow or radial flow of urban transportation. These corridors, such as the northeast corridor between Washington, D.C., and Boston, the Pacific corridor between San Diego and San Francisco, and others that are forming, typically have high flows of people moving along them. These people travel chiefly by automobile and air, to the extent that these modes of transportation are near their capacities for safety and efficiency.

The present study is concerned with ways to provide a safe, high-capacity system that will not add to the burgeoning problems of air pollution, noise, and artificial resectioning of communities. The study is restricted to ground (and below-ground) transportation systems.

Many factors are involved in evaluating the methods of providing this transportation system with today's technology, particularly in the light of what can be achieved by vigorous development programs in specific areas. This profusion of interacting elements leads naturally to the application of the disciplines of systems engineering in seeking an optimum solution to the transportation problem. The work reported here is a part of such an overall systems engineering effort.

In applying the techniques of systems engineering to the problem of providing safe, economical, high-capacity transportation that will be attractive to travelers in an urban corridor, the analysis moves from the evaluation of the general morphology of all possible ground transportation methods through mathematical modeling of interacting areas to the definition of specific systems that emerge from the analysis. The systems that have been so differentiated in the study are as follows:

- High speed rail vehicles
- Tracked air cushion vehicles
- Tube vehicle systems
- Monorails
- Automated highway systems
- Multimodal systems

Each of these is chosen to solve the problem in a different way. The comparable advantages and disadvantages are to be evaluated in the overall system model in working toward the selection and implementation of a system.

The systems are each characterized in terms of a central baseline system that is defined in some detail, together with parametric variation of data about this baseline. The effects of varying particular attributes of the system, such as vehicle length, speed, or control method on other parts of the system, on its costs, or on its performance can therefore be understood. The conversions from engineering specifications to costs are not explicitly part of this study, but are reported in the cost section on the basis of data from Resource Management Corporation.

The qualities desired in the transportation system, as characterized by the Department of Transportation, are as follows:

- High predictability of arrival time
- Low door-to-door travel time from traveler's point of departure to his ultimate destination
- High flexibility of service to meet variations in service demand
- High degree of safety, comfort, and convenience
- Evolutionary growth capability
- Low degree of undesirable effect on surrounding environment

In this relationship, the system should offer low cost per seat mile and high cost effectiveness, consistent with the quality of service needed to maintain its position of market acceptance.

The study culminates in four major areas of results. First, the areas of development, testing, and evaluation that are needed to implement the identified systems are delineated. Second, a description on which preliminary design can be based is provided for each system and subsystem, together with the analyses supporting these descriptions. Third, cost versus performance is calculated parametrically for each candidate baseline system. Fourth, qualitative evaluations suitable for comparison of the systems are developed.