TECHNOLOGY ASSESSMENT OF FUTURE INTERCITY PASSENGER TRANSPORTATION SYSTEMS

Volume 1
Summary

Prepared By

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The views and conclusions presented in this report are those of the staff of the Technology Assessment Team and do not necessarily reflect those of the National Aeronautics and Space Administration or the U.S. Department of Transportation.

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VOLUME 1
SUMMARY REPORT

Prepared For

National Aeronautics and Space Administration
and
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1 INTRODUCTION

Study Objectives

The technology assessment of intercity transportation systems was sponsored jointly by the National Aeronautics and Space Administration (NASA) and the U.S. Department of Transportation (DOT). The purpose of the study was to assess technical, economic, environmental, and sociopolitical issues associated with future intercity transportation system options. The NASA/DOT Oversight Committee for the project noted that:

> "A goal of this technology assessment is to assess the impacts of new transportation technologies on society and to identify potential problems, drawbacks, and advantages of individual technologies.
>
> "A second goal is to identify research and analysis tasks to alleviate negative impacts, to augment positive impacts or to better understand these impacts. We hope to develop valuable insights to societal benefits or problems produced by the potential introductions of the technologies, and to develop recommendations for research and technology efforts toward improving the impacts.

The emphasis was on domestic passenger transportation, but interfaces with freight and international transportation were considered.

Purpose of Technology Assessment

The term "technology assessment" is intended to identify a particular approach to the analysis of technological innovation. However, the concept is relatively new and a number of different kinds of research efforts have been termed technology assessment studies. Even though a consensus on the meaning of technology assessment has not been established, the following is an example of the principles that were considered in this project:

> "Technology assessment is a class of policy studies which systematically examine the effects on society that may occur when a technology is introduced, extended, or modified with special emphasis on those consequences that are unintended, indirect, or delayed."
>
> —Joseph Coates
> Office of Technology Assessment
> U.S. Senate

Thus, technology assessment studies can provide a broad appreciation of impacts and implementation problems and may contribute to improved research and technology decisions.

Experimental Nature of the Project

This study was an experiment in the use of technology assessment as a tool to assist in the identification of basic research and technology development tasks that should be undertaken. Among the experimental features of this project (particularly in combination) were the following:

- The study's broad scope—encompassing all intercity passenger transportation (and interactions with freight service) to and beyond 2000 A.D.
- The use of scenarios to describe alternative future settings and intercity transportation development.
- The use of a joint industry (consultant)/university/government team to perform the study.
- The formation of a group of "study participants" from government, transportation and other industry, and academic institutions to review and contribute to the progress of the project.

It is expected that forthcoming studies will continue to experiment with these and other possible features of a technology assessment, seeking improved ways to define project objectives and scopes and continuing to refine study methodologies.

About This Volume

This volume summarizes project activities, but only gives a brief overview of project documentation. Although some readers can scan selected chapters in this volume to find needed information, others will have to refer to another volume for more detailed information. Other volumes of the study's final report are the following:

Volume 2 – *Identification of Issues Affecting Intercity Transportation*

Volume 3 – *Technological Characteristics of Future Intercity Transportation Modes*

Volume 4 – *Study Scenarios*

Volume 5 – *Workshop Proceedings*

Volume 6 – *Impact Assessment*

Volume 7 – *Study Recommendations*

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STUDY APPROACH

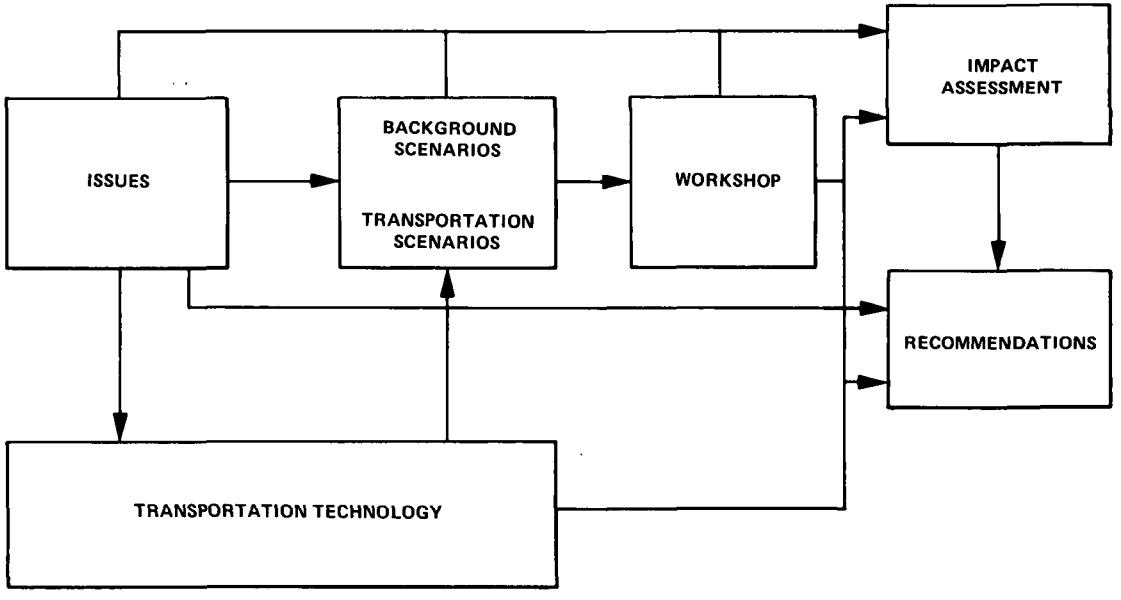
The overall approach to conducting the project is shown in the summarized task flow chart below.

During the first half of the 13-month study, project team members conducted an analysis of intercity transportation system options to the year 2000. Initial tasks of this effort included the identification of issues affecting the future of intercity transportation and the identification of candidate transportation technologies. Work on these two tasks continued throughout the study.

In the issues task, papers were prepared by individuals representing diverse backgrounds and interests. The majority of the papers set forth viewpoints on social, political, institutional, and economic mechanisms which will influence the way that transportation technologies will evolve and be put into service.

The technology task focused on the future performance characteristics of present intercity modes and possible new technological forms of transportation. Modes were considered within general classes such as air, rail, high-speed ground (levitated), and highway transportation.

The project team's assessment of intercity transportation system options was carried



out within the framework of scenarios. Background scenarios were developed to describe four different states of society in the year 2000. Then, for each background, a transportation scenario was developed and analyzed. Each of the transportation scenarios included a variety of postulated transportation innovations.

At the midpoint of the study, a week-long Workshop was held to identify and assess impacts related to future transportation alternatives. The Workshop was attended by the project team and 40 invited study participants from government, industry, and academic and other institutions. Participants were selected early in the project, and they made contributions throughout the study by reviewing draft reports.

After the Workshop, project team efforts focused on the continued assessment of impacts related to possible future intercity transportation innovations and the development of study recommendations.

The study approach led to the identification of a large number of possible direct and indirect consequences of technological developments that may occur in intercity transportation during the next 25 to 50 years. Some of these impacts are well understood and are seen as likely. Consequences of this kind have led to study recommendations regarding the characteristics of future intercity transportation modes. Many other possible impacts are only hazily perceived and their likelihood is uncertain. In these instances, study recommendations are oriented toward further research and analysis activities.

In addition to the Study Recommendations (Volume 7), the following are considered to be important outputs of the project:

- The diverse opinions contained in the study's issue papers (Volume 2)
- The compilation of intercity transportation technology data (Volume 3)
- The study's approach to impact assessment (Volume 6)

Moreover, the study approach has provided some insights on the technology assessment process. Some of these insights are outlined in the box below; these and others are described in Volume 7, Study Recommendations.

STUDY TEAM FINDINGS ON THE TECHNOLOGY ASSESSMENT PROCESS

"What if" questions are central to a technology assessment. It is important to pose these questions properly. Without sufficient analysis, there is a danger of assuming away the impacts that are sought. On the other hand, too much effort can be devoted to the analysis of the direct effects of a technological innovation and not enough effort to the more difficult search for secondary and unanticipated impacts.

The study team found that there is an apparent tendency for nontechnologists who participate in the technology assessment process to focus on negative attributes and uncertainties regarding an innovation, rather than positive impacts.

Technology assessment requires the input of many disciplines. The fact that these inputs are difficult to organize and document presents a major challenge to making a technology assessment valuable. The workshop concept has potential for bridging the "communication gap" between disciplines. However, it appears that the group dynamics of a technology assessment workshop are likely to produce compromise positions rather than controversial unanticipated impacts.

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ISSUES

The issues task addressed major issues and trends that will affect the future of intercity transportation. Papers were prepared by individuals representing a diverse array of backgrounds and viewpoints, in an effort to assemble a substantial collection of discussion material.

The papers describe a variety of mechanisms that influence the way transportation technologies will evolve and be put into service. In some cases, the authors argue for change of existing mechanisms (e.g., regulatory reform) or advocate specific technologies (e.g., electric highway vehicles). Other papers explore trends affecting intercity transportation such as economic growth.

This section summarizes the issue papers in selected subject areas.

Society and Politics

Since intercity transportation systems provide an essential service affecting segments of society, it is important to try to match systems' development to societal wants. While many of these wants may seem obvious, many other wants cannot be fully articulated. Moreover, society is often unable to compromise on competing wants. This suggests that major intercity transportation programs must exhibit the properties of variety, suitability to incrementalism, flexibility, exhibition of short-term benefits, and, especially, broad geographic and demographic incidence of benefits.

The future geographic distribution of population and wealth is largely dictated by trends that can be observed today. Even extreme assumptions regarding social policy and economic developments, when systematically traced through to demographic implications, do not seem to yield significant differences in possible settlement patterns for the next 25 years. The economic resources at the command of the population are, however, subject to considerable future variability, depending upon the future state of the economy and public policies.

Current political realities dictate that no major publicly funded transportation program can be undertaken without evidence of direct benefits to some large percentage of the nation's congressional districts. The implication is that there must be a serious search for institutional and technological developments that will permit piecemeal and widespread infusion of proposed improvements, simultaneously in many locations throughout the country.

A key criterion for any major transportation improvement program, under current political conditions, is substantial opportunity for private sector involvement in the enterprise. Evidence is clear that private sector resistance to a proposal, on the grounds of overt public competition, is generally sufficient to kill any public transportation program.

The options are either to recognize and deal with the system, as is, or attempt to bring about a basic change in the political system to accommodate other forms of implementation.

The U.S. political system is steadily becoming more and more complex, involving multiplication of interest groups and special purpose agencies, with an attendant proliferation of policy options. These trends are causing, and will continue to cause, difficulties in reaching consensus on any major policy matter. Simple governmental reorganization seems of little help. The possibility of continuing our current political forms into the future may depend, in part, on the generation and careful use, in the political process, of information on the incidence of program costs and benefits. Such considerations must be given considerable weight in the development of major transportation development programs. Even with enlightened government action, it is unclear that improvements in the deliberative process can keep pace with the barriers to effective policymaking posed by these trends toward greater and greater complexity. Whatever the outcome, there is little doubt that the overhead consumed by that process (e.g., Environmental Impact Statements) will continue to expand in the future.

A key social impediment to any major future transportation innovation may be a growing popular aversion to "bigness." Proposals for innovation must explicitly come to grips with this problem.

The Environment

No one can chart the exact course that the environmental movement will take in future years, or its implications for intercity transportation. It seems clear that the intense feeling of the late 1960s has moderated somewhat, and environmental concern is now often being traded off against other objectives. One can see a mixed pattern of feelings on environmental matters emerging, where the level of concern in each geographic area is matched to its economic structure, its endowments, and its political constituency. While evidence of a trend toward balanced application of environmental laws is generally evident, geographic disputes and concern over the economic health of the country and the world could bring about conditions for considerable future divisiveness in dealing with environmental matters, with concommitant obstruction of needed development programs.

Technology and Organization

Considerable opportunity for intercity transportation system improvement lies in the technological and institutional integration of the line-haul and collector-distributor functions of current and future transport technologies. Since all transport systems exhibit significant economies of scale, society must carefully guard against overemphasizing the gains realizable in high-density line-haul, at the expense of the total door-to-door journey. Current economic analysis methods, financing, and ownership patterns for intercity transport significantly exacerbate this problem, but also reveal possibly fruitful areas for improvement.

A transportation supply system may be viewed as the combination of vehicles, ways, and driver skills. Fragmentation in patterns of ownership and responsibility for technology delivery has often resulted in a history of sequential suboptimization of the separate components. The resulting system may be quite different than what could have been achieved through overall system optimization. Herein, perhaps, lies an opportunity for significant technological and institutional innovation.

The future of intercity transportation depends primarily upon the evolution of the technology and technology-delivery systems associated with the automobile. Those systems, in turn, are heavily dependent upon the availability and disposition of personal wealth, and the mechanisms of growth, stagnation, and change within the automobile industry. While the future path of development for the automobile remains largely in doubt, there is evidence that points to major changes in both the nature of automobile technology and in patterns of automobile use during the next few decades. Whether these forces for change will be understood and controlled to improve the effectiveness of the personal transportation systems that finally emerge is a major question for which no ready answer is now available.

The future of transportation technology will be influenced significantly by foreign innovators, despite entry barriers to U.S. markets. This influence will be a mixture of direct introduction of foreign technology and local duplication of this technology by domestic entrepreneurs. Presumably, as the world sense of community increases, the balance will tilt towards the former means of influence.

List of Study Issue Papers

Current and Future Forms of Intercity Passenger Transportation — W. L. Garrison, University of California, Berkeley

Constraints to the Implementation of Intercity Transportation Innovations — A. J. Gellman, J. P. Price, J. J. Grocki, and R. P. Whorf, Gellman Research Associates, Inc.

The Congressional Politics of Transportation Expenditure: Implications for the Future — David W. Jones, Jr., and James F. Miller, Jr., Stanford University

Macroeconomic Issues Through the Year 2000 — R. U. Ayres, International Research and Technology Corporation

Financial Issues Impacting Intercity Transportation — J. P. Price and R. W. Luce, Gellman Research Associates, Inc.

The Cost-Revenue Squeeze in Highway Finance — David W. Jones, Jr., University of California, Berkeley

Interactions Between Capital Funds Sources and Technological Changes in Rail and Air Passenger Transport — J. P. Price, Gellman Research Associates, Inc.

Issues in Regulation of Intercity Transportation — J. J. Grocki, J. P. Price, and R. P. Whorf, Gellman Research Associates, Inc.

The Impact of Deregulation — J. P. Price and D. Greenstein, Gellman Research Associates, Inc.

Organizational and Regulatory Issues — J. P. Carter and B. Bernhard, University of California, Berkeley

Resource Availability Inputs to Intercity Transportation to the Year 2000: With Special Reference to Energy Resources – H. W. Bruck, University of California, Berkeley

The Future of Concern for the Environment – Robert H. Doyle, Richard W. Schmidt, and D. Michael Cullivan – Peat, Marwick, Mitchell & Co.

Social Impacts on Intercity Transportation– Robert P. Whorf and William White, Jr., Gellman Research Associates, Inc.

A Note on Technology Pessimism – W. L. Garrison, University of California, Berkeley

The Effects of Existing Capital Stocks on Technology Assessments – J. P. Price, W. B. Allen, and R. P. Whorf, Gellman Research Associates, Inc.

The Transportation/Communication Trade-off – David W. Jones, Jr., Stanford University

Intercity Technology and Organization: A Proposal – J. P. Carter, University of California, Berkeley

The Auto-Industrial Era – Is It At An End?– John Mollenkopf, Stanford University

Electric Highway Vehicles: A Way to Save Our Mobility, Air, Energy, and Fortunes – Richard B. Fradella

Automobile Durability – James F. Miller, Jr., University of California, Berkeley

Energy Considerations in Goods Transportation – Ernest Koenigsberg, University of California, Berkeley

Trends in Freight Transportation: 1975 to 2000 – Vincent Roggeveen, Stanford University

Transportation/Communication Trade-Offs

Future communication technologies will offer high quality telecommunications and data transmission features closely approximating the information-exchange capabilities of face-to-face communications. However, it is impossible on this basis to predict a net decrease in the need for travel. Although some reduction in the need for current types of trips may be possible, it is also necessary to anticipate an expansion of opportunity for human interaction that will generate a considerable amount of new travel. Thus, it is not possible to see any overall lessening of the need for travel in the future due to communications technology development.

Finance

It is not at all clear whether the financial resources to support future intercity transportation development will be available. Large dollar amounts will be required to maintain acceptable levels of service in existing highways, airports, and rails, without considering proposals to provide new significantly improved facilities and services. Existing transportation funding sources are clearly incapable of providing the needed resources. Important financial breakthroughs must occur in the future to prevent the collapse of current services, as well as finance any desired new programs.

There is an apparent national political shift away from further development of highways and toward greater expansion of public passenger transport. However, it is not clear what the implications of this trend will be for intercity transportation. It is questionable whether recent congressional actions that have markedly increased the funds for urban transit improvements will carry forward a philosophy for improving analogous intercity systems.

Labor

Countervailing forces exist which make it difficult to estimate the future size and composition of the labor force and, hence, productive capacity. On the one hand, declining birth rates and the potential for a significant social "dropout" rate suggest a significant future decrease in both the proportion and absolute number of workers in the population. On the other hand, the future may bring such a large increased involvement of women in all aspects of business that the effects of the above trends may be significantly diluted. To a great extent, the resulting size of the labor force is a policy variable that can be influenced by public, social, and economic programs.

Implementation of technological and institutional innovation in intercity transportation is generally dependent upon the concurrence of labor unions. Design of suitable incentives to obtain such concurrence must be included in any serious proposal to improve intercity transportation. The history of transport innovation contains examples of both insightful and clumsy handling of labor union interests. Such experiences can provide valuable guidance toward methods to assuage potential labor resistance to desirable transport improvements.

Energy

The coming decade will be a most critical period from the point of view of U.S. vulnerability to scarcities and price gouging in energy supplies. It will be a period in which the country must choose between very heavy capital investment, just to keep energy supplies arriving at a somewhat expanded rate, or mammoth investment both to keep current supplies coming and to pursue the long-range objective of national energy independence. In either event, energy-related investments will command a dramatically increased share of the future GNP, making significant inroads into financial resources available for other purposes, particularly intercity transportation. Under these conditions, it is difficult to envision more than incremental, state-of-the-art intercity transportation investments through the year 2000. If, however, energy R&D pays off near the end of the century in practical fusion or artificial fuel technologies, the first half of the 21st century could bring considerable innovation in intercity transport technologies.

Regardless of government energy policy, future scarcities and price increases for transport fuels are likely. Under a vigorous Project Independence, these effects are likely to occur in the near term, due to conscious policy. Under a vacillation policy, these effects would probably come later, and much more disruptively. In either case, the effect on intercity transportation service and travel is not likely to be extreme, since energy does not account for a large percentage of intercity transportation costs. However, if energy costs rise severalfold and begin to dominate other cost components, the restructuring effects will be felt first in nonessential areas, such as personal leisure and vacation travel. The most disruptive situation for intercity transport involves the possibility of government response to shortages through rationing, which could impact across the board, affecting all kinds of personal and goods transport.

National policy and market mechanisms responding to recent and possible future increases in energy costs and the state of the economy may dictate a major readjustment of previous equilibria now reflected in the national pattern of goods production and distribution. Careful scrutiny of the cost trade-offs existing among different transport modes, and of the trade-off between decentralized production, on the one hand, and centralized production with high transport costs, on the other, could produce a new pattern involving shifts in industrial location and concommitant transport demand. Such shifts may have important new unforeseen implications for the development of transport service and supporting technology.

Regulatory Control

Government regulatory policies can be formidable barriers to some forms of technological and organizational innovation in intercity transportation. However, regulatory agencies may now be facing a major redefinition of their proper role and methods in this area. Proposed improvements to transportation infrastructure, equipment, and service must relate to the different forms of federal and state regulatory activites that may emerge in the future.

Although a broad range of economic and noneconomic constraints to transportation implementation must be considered in connection with any serious proposal for innovation, three key elements warrant careful consideration — the locus of regulatory power, the national policy position regarding the proper balance between competition and economies of scale, and the underlying social climate, or "social awareness." Currently, these and other considerations create a climate seemingly quite hostile to significant transportation innovation.

Some lack of performance in transportation regulation and technology development is certainly caused by a tendency to apply past workable solutions to new problems, even though these past solutions may not be entirely suitable. This tendency reflects a legitimate need in public policymaking to make problem-solving processes routine rather than to try to solve each new problem from basic principles. Clearly, however, there is a need to design and institute higher-level policies in government that cause solutions to change when the problems change significantly. The mechanisms for doing this are not now apparent.

Many critical investment and regulatory decisions affecting intercity transportation are generally sensitive to the state of the economy and specifically sensitive to the state of transportation business conditions. Transport regulation tends to respond to national economic and resource crises and to be largely overlooked in favorable economic times.

A cogent argument can be made that complete deregulation of intercity transportation is a sure invitation to eventual dominance of the sector by a small number of giant, uncompetitive companies. This and other reasons suggest that regulatory reforms will be applied in an incremental and cautious manner. The future may bring even more government regulation of intercity transport than currently exists, although perhaps of a significantly different nature.

4
TECHNOLOGICAL CANDIDATES

The technology task of this study focused on the future performance characteristics of present intercity modes and possible new technological forms of transportation. Knowing that there were hundreds of intercity transportation technological forms or variations in which the guideway, suspension, propulsion, energy requirements, pollution, noise, or other characteristics differ, the technology team chose to separate modes into general classes such as air transportation, improved rail passenger transportation, high-speed ground (levitated) transportation, and highway transportation.

In this section, a brief summary of some of the modal possibilities is given. Included are the essential technological characteristics, their advantages and disadvantages, and the technical advances or breakthroughs, if any, that appear necessary for implementation of the mode.

It is important to avoid confusing the "most-likely transportation modes" for the future and desirable future research and development activities. These activities are intended to create new knowledge that may contribute to the development of an economically viable system with desirable service and performance characteristics. One never knows in advance what the results may be. Although certain technological developments may be less likely to become operational based on current information, technological breakthroughs or inventions may change the feasibility of these concepts. For example, in 1947, jet transport studies showed maximum ranges of about 750 miles and poor economics. Sweepback was a threat to flying qualities. Many were fearful of the pressurization of passenger cabins at altitudes above 30,000 feet. Twelve years later jet transports revolutionized travel.

Although there is currently a lack of optimism regarding some aircraft or ground transportation forms, basic research and technology development in all transportation areas should be continued and constantly reviewed. The results may bear fruit in unexpected ways.

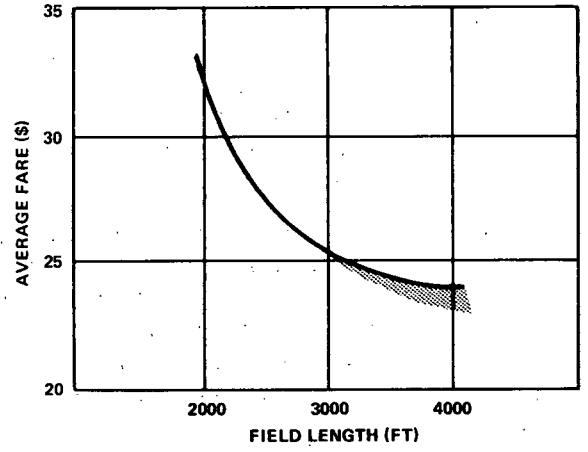
AIR TRANSPORTATION

Advanced Technology Subsonic Transports. Provide current speeds (± 10%) with less fuel consumption (30% below widebody transports) and lower seat-mile cost (-12%). Utilize improved transonic airfoils which permit thicker less-swept wings at any design speed, thereby saving structural weight; composite materials (graphite or boron fibers in any epoxy matrix) which save significantly in structural weight; active controls which permit reduced stability and thus save tail surface drag and weight; improved propulsion technology, which results in some modest efficiency gains; possible small aerodynamic improvements such as winglets; and designs optimized for high fuel costs, i.e., higher aspect ratio (span). Logical next generation aircraft. Requires extensive service tests of composite materials to prove acceptable life characteristics.

CONVENTIONAL SUPERCRITICAL

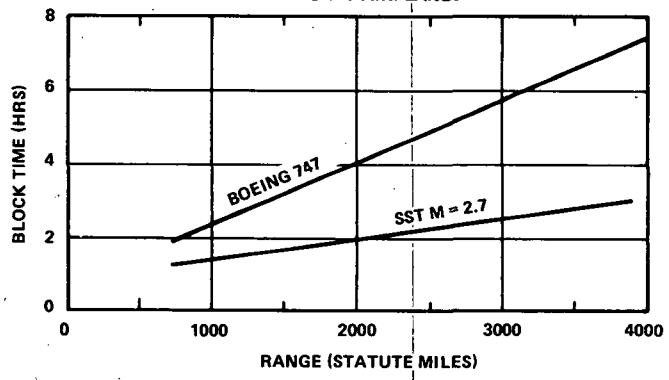
Short Takeoff and Landing (STOL) Aircraft. Utilize propulsion system to substantially increase lift and permit short takeoff and landing distances; have higher operating and investment costs than conventional aircraft as well as higher fuel usage. Economic and energy disadvantages probably will prevent commercial use except in special circumstances, e.g., mountain recreational airstrips. Speed range from Mach number 0.6 to 0.8.

FARE VS. DESIGN FIELD LENGTH IN THE CALIFORNIA CORRIDOR FOR QUIET PROPULSIVE LIFT AIRCRAFT (1972 DOLLARS)



Supersonic Transports (SST). Have high cruise speeds, two to three times faster than sound. Trip times reduced by 45% to 55% on transatlantic ranges. Present Concorde aircraft have direct seat-mile costs triple and total costs double those of present widebody subsonics, fuel usage three times as high as subsonics. Second generation SST with today's technology would have direct costs considerably less than double and total costs 40% to 50% higher than 747; fuel usage 2 to 2.5 times as great per seat-mile. Sonic boom problems would have to be resolved by currently unknown means to permit domestic use. Sonic booms and current estimates of costs indicating high break-even fares will limit market. Require huge development investment beyond scope of private industry; require major breakthrough in propulsion (e.g., variable cycle engine) plus gains in aerodynamics and materials to compete economically. Also need intense engine development to reduce nitrogen oxides in exhaust because of potentially serious upper atmosphere ozone-layer threat.

COMPARISON OF BLOCK TIMES FOR THE BOEING SST AND 747 AIRPLANES



OTHER AIR TECHNOLOGIES CONSIDERED:

Laminar flow control
Nuclear-powered aircraft
Vertical takeoff and landing (VTOL) aircraft
Hydrogen-fueled aircraft
Hypersonic transports
Lighter-than-air
Turboprop (propfan) aircraft

SURFACE TRANSPORTATION

Improved Passenger Train (IPT). Utilizes traditional twin steel rail, small improvements in existing guideways, advanced suspension systems, and high power-to-weight propulsion. Will permit speeds of 80 to 120 mph. Offers improved block times with minimum investment.

Advanced High-Speed Train. Requires new twin-rail high-quality guideways with large radius curves, shallow grades, completely seperated rights-of-way, together with advanced propulsion systems such as linear induction motors; speeds up to 250 mph design limit for rail. Offers further improvement in block time at substantial guideway investment costs, about $3,200,000 per mile plus land and tunneling (or underpass) costs.

Bus. Provides public transportation service using the highway system. Gas turbine propulsion may improve economy and passenger comfort. Requires minimum investment; has flexible route capability; is lowest cost common-carrier mode. Block speed equals 50 mph under current speed limits.

Automobiles. Provide privacy, convenience, and comfort at low perceived cost, but at lower speeds than nonhighway modes. Improvements in engines, transmissions, and designs are expected to improve fuel economy by over 90% while maintaining acceptable emission standards. Block speed equals 50 mph with current speed limits. Will always be a popular intercity mode.

Automated Highways. Provide high-speed automatic control of automobiles or buses on highways. Based on radar or laser sensing of guiding stripe. Require redundant control in the vehicle for safety. Would have a significant cost impact. Continuation of current speed limits would reduce its potential value.

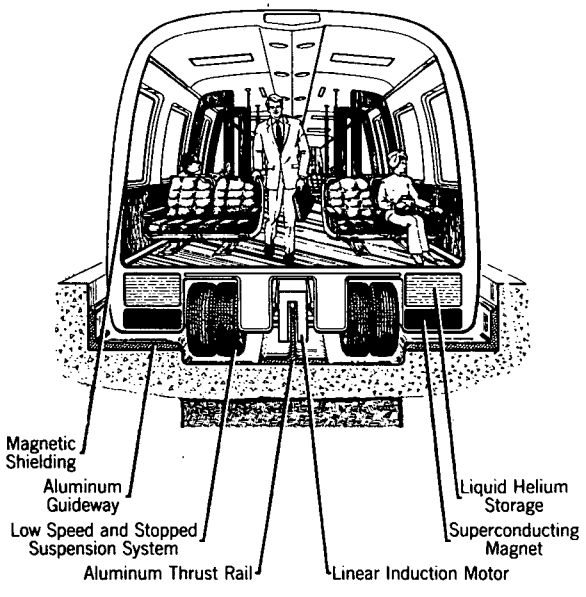
Multimode Vehicles. Would be small, possibly electric, vehicles with local range but operable on an electrically powered guideway for intercity travel. Requires special guideway or special lanes on normal highway.

Tracked Levitated Vehicles (TLV). Provide maximum speed range from 250 to 600 mph. System cost is dominated by guideway costs. Three noncontact suspension technologies are available. Costs are comparable.

- Tracked Air Cushion Vehicle (TACV): Fan or ram driven air is pushed through a large skirt (plenum) for suspension.
- Magnetic Levitation (Repulsion): Motion of superconducting magnets over aluminum-lined guideway produces repelling magnetic field for suspension.
- Magnetic Levitation (Attraction): Electromagnets attracted upward toward steel rails for suspension.

Propulsion options include linear induction motors, linear synchronous motors, or gas turbines (noisy).

Fares become reasonable for short to medium ranges and very high demand. Travel times between city centers might be better than with aircraft.



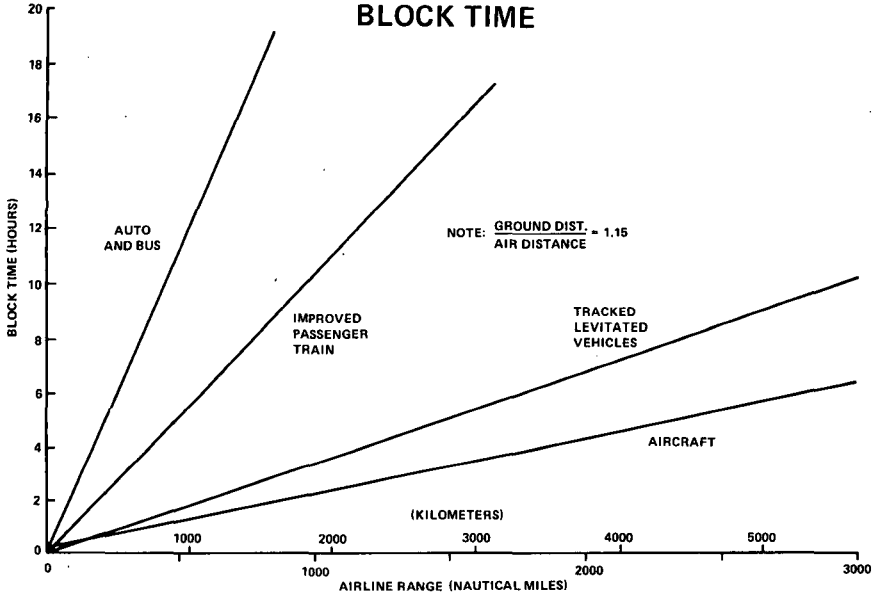
OTHER SURFACE TECHNOLOGIES CONSIDERED:

Auto-Train systems

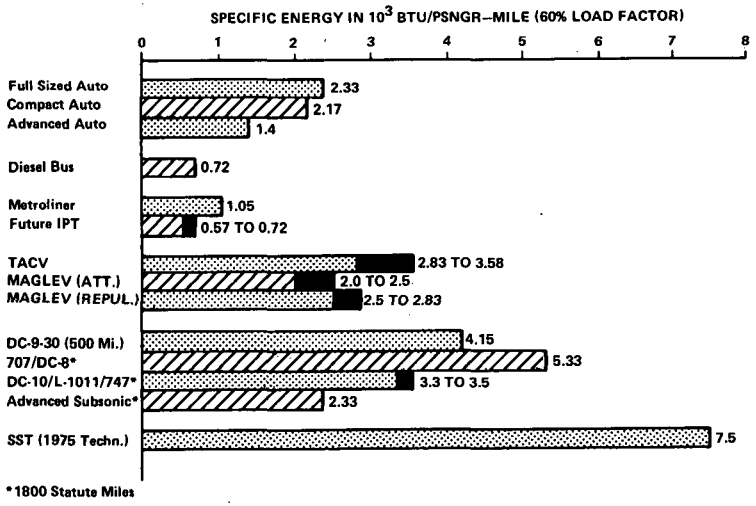
Tube concepts

COMPARISONS OF MODAL CHARACTERISTICS

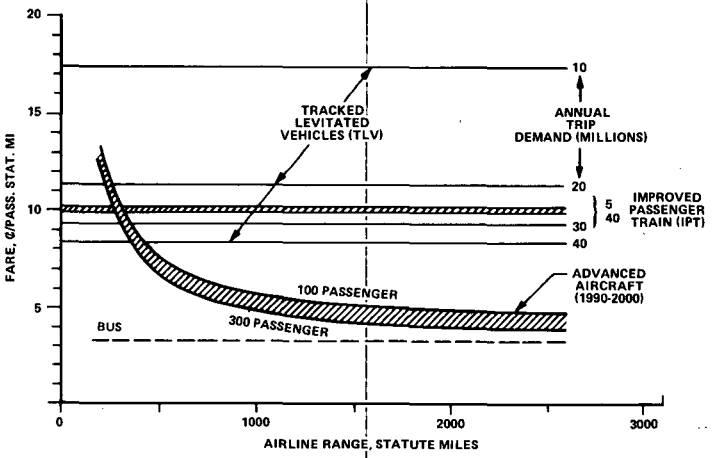
BLOCK TIME



ENERGY CONSUMPTION



COMPARATIVE FARES *



*This comparison is based on calculated fares (1974 prices) required to cover:

- Direct and indirect operating costs
- Amortization of the infrastructure investment (when not accounted for in indirect costs or a ticket tax)
- An 8% after tax profit on vehicle investment

See Volume 3 for other assumptions.

5 SCENARIOS

Scenarios were used in this study to provide a structure for assessing alternative future transportation technologies and policies. Direct forecasting of a presumed "most likely" state of the nation was rejected as an approach because of the lack of credibility that any one such forecast would contain. Scenarios were adopted to assist in focusing debate by providing several possible and interestingly different futures in which to study the implications of transportation options.

"Background scenarios" were developed to describe four different states of society in the year 2000. Then, for each background scenario, a "transportation scenario" was developed and analyzed.

Background Scenario Settings

The factors that were systematically varied among the four background scenarios included the following:

- National viewpoint on public services and economic development, level of prosperity, and capital formation
- Population growth and settlement patterns, life-styles
- Resource (e.g., energy) costs
- Government regulatory controls, levels of R&D expenditure

Issue papers and other analyses contributed to the development of background scenarios.

Transportation Scenario Innovations

A number of different intercity transportation innovations were postulated in the context of each background scenario. The scenario descriptions included consideration of how year 2000 intercity transportation systems might evolve from those currently in operation.

The characteristics of the assumed transportation systems were generally based on results of the study's technology task, but in some cases more advanced characteristics were postulated. The primary purpose of these extrapolations was to provide for wide-ranging future possibilities that may result from currently unforeseen technological breakthroughs.

Analysis of Scenarios

A qualitative analysis of the transportation scenarios was conducted to estimate changes in patronage, cost-revenue relationships, energy consumption, and traffic safety resulting from the introduction of postulated innovations. The analysis design included selected "travel settings" and "reference cases" as a basis for measuring scenario effects.

Travel Settings

Travel corridors and city-pair travel markets were selected as case examples for the introduction of scenario innovations:

- High-Density Travel Corridors, e.g., Boston-New York-Washington, D.C.
- Large City-Pair Markets, e.g., Los Angeles-Washington, D.C.
- Smaller and/or Shorter Distance City-Pair Markets, e.g., Denver-Billings

The selected travel settings were viewed as case examples of the potentially more widespread introduction of new technologies.

Reference Cases

To provide a basis for measuring impacts of the transportation systems postulated in a given scenario, a set of four reference cases was constructed — one reference case for each background/transportation scenario. The common feature among the four reference cases is that each has the same transportation technology for the year 2000; for all modes, only nominal improvements, if any, were postulated relative to today's systems (e.g., marginally improved fuel efficiency for automobiles). The reference cases differ from one another, however, because of background scenario conditions: population, income, wage rates, cost of capital, and price of fuel. Whenever a term such as "higher" or "lower" is used in describing a transportation scenario, it relates to the reference case for that scenario. Because of variations in both transportation innovations and background conditions, comparisons of numerical results cannot be readily made between transportation scenarios.

SCENARIO I

SETTING

National emphasis is on economic development and encouragement of business . . . Relaxation of many business controls . . . Considerable growth in wealth and capital formation . . . Worsening international tensions, resource cartels, and economic warfare . . . High capital and resource costs . . . Considerable R&D and large-scale innovation . . . Privately financed transportation innovations in dense markets, minimal service in sparse markets.

TRANSPORTATION INNOVATIONS

	HIGH-DENSITY CORRIDORS	LARGE CITY-PAIRS	SMALLER/CLOSER CITY–PAIRS
AIR	REDUCED FARES, BUT ALSO REDUCED FREQUENCY	SST 900-PASSENGER JETS FASTER CTOL*, WITH REDUCED FREQUENCY	DISCONTINUED SERVICES
	← IMPROVED AIR TRAFFIC CONTROL →		
RAIL	SOME IPT (IMPROVED PASSENGER TRAIN)	MOSTLY DISCONTINUED	NOT AVAILABLE (AS AT PRESENT)
BUS	← 70-MPH SPEED LIMIT →		
AUTO	SOME ELECTRIC HIGHWAYS		

*CTOL denotes conventional takeoff/landing aircraft

ANALYSIS RESULTS

PATRONAGE
- INCREASES . . . . . IPT, ELECTRIC HIGHWAYS, SST
- DECREASES . . . . . "CORRIDOR-AIR," 900 PASSENGER JET

NET REVENUES
- HIGHER . . . . . AIR, RAIL (IPT), BUS

ENERGY CONSUMPTION
- LOWER PER PASSENGER-MILE
- HIGHER IN TOTAL

TRAFFIC SAFETY
- LITTLE CHANGE

SCENARIO II

SETTING

National emphasis is on restraint of big business and big government and encouragement of competition and entrepreneurship . . . Control of large corporations through forced public disclosure, antitrust, and some nationalization of foundering companies . . . Steadily increasing population oriented to medium-size and nucleated cities . . . Moderate growth in wealth and capital formation . . . Some relaxation of international tensions and favorable trade conditions . . . High capital and moderate resource costs . . . Considerable R&D and diffuse innovation . . . Considerable transportation innovation.

TRANSPORTATION INNOVATIONS

	HIGH-DENSITY CORRIDORS	LARGE CITY-PAIRS	SMALLER/CLOSER CITY-PAIRS
AIR	SHORT RUNWAY AIRCRAFT	LOWER FARES FOR CTOL	COMMUTER SERVICES
RAIL	IPT	← DISCONTINUED →	
BUS	← MORE COMFORTABLE, LOWER FARES →		SOME SMALL VAN SERVICE
AUTO	← IMPROVED FUEL CONSUMPTION →		
OTHER	← ACCESS/EGRESS IMPROVEMENTS →		

ANALYSIS RESULTS

PATRONAGE
- INCREASES . . . . . IPT, SHORT RUNWAY AND COMMUTER AIR; BUSES

NET REVENUES
- HIGHER . . . . . IPT, LARGE BUSES, SHORT RUNWAY AND COMMUTER AIR
- LOWER . . . . . VAN BUSES (SUBSIDIZED)

ENERGY CONSUMPTION
- MIXED RESULTS

TRAFFIC SAFETY
- LITTLE CHANGE

SCENARIO III

SETTING

Political leadership is consensus-oriented with flexible policies aimed at mediating competing demands of well-organized interest groups . . . Growing complexity and inefficiency in public and private services, with increasing government subsidy in many areas . . . Slow population growth concentrated in existing cities and suburbs . . . Extremely slow economic growth . . . Moderate capital costs . . . Moderate resource costs initially, followed by a severe energy crisis in the 1990s . . . Moderate R&D expenditures with slow implementation of innovations.

TRANSPORTATION INNOVATIONS

	HIGH-DENSITY CORRIDORS	LARGE CITY-PAIRS	SMALLER/CLOSER CITY-PAIRS
AIR	← HIGHER FARES →		REDUCED FREQUENCY →
RAIL	IPT	← INCREASED FREQUENCIES →	
BUS	← LOWER FARES →		
AUTO	← REGULATIONS CURTAIL INTERCITY USE →		
OTHER	← ACCESS/EGRESS DEGRADED →		

ANALYSIS RESULTS

- PATRONAGE
  - INCREASES . . . . . IPT, BUS
  - DECREASES . . . . . AUTO, AIR
- NET REVENUES
  - HIGHER . . . . . IPT
  - LOWER . . . . . AIR, BUS, RAIL
- ENERGY CONSUMPTION
  - LOWER PER PASSENGER-MILE
  - LOWER IN TOTAL
- TRAFFIC SAFETY
  - FEWER PASSENGER FATALITIES

SCENARIO IV

SETTING

A strong political coalition has emerged that is committed to ambitious social and economic reform . . . Strict government control of key enterprises and eventual government ownership of many . . . Major growth in public services . . . Steadily increasing population oriented to medium-size cities and nucleated metropolitan areas . . . No-growth economic policy . . . Considerable relaxation of international tensions . . . Low capital and moderate resource costs, but with heavy taxation of private resource use . . . R&D closely focused on national social priorities, yielding significant innovations in energy production and transportation.

TRANSPORTATION INNOVATIONS

	HIGH-DENSITY CORRIDORS	LARGE CITY-PAIRS	SMALLER/CLOSER CITY-PAIRS
AIR	REDUCED FREQUENCY OF SERVICE	CHEAPER, FASTER CTOL	IMPROVED SMALL AIRCRAFT SERVICES
	← IMPROVED AIR TRAFFIC CONTROL →		
RAIL	TLV	MOSTLY DISCONTINUED	SOME NEW ROUTES
BUS	← LOWER FARES →		
	75-MPH SPEED LIMIT		
AUTO	← IMPROVED FUEL CONSUMPTION →		
OTHER	← LARGE IMPROVEMENTS TO INTERCITY ACCESS/EGRESS BECAUSE OF URBAN TRANSPORTATION IMPROVEMENTS →		

ANALYSIS RESULTS

- PATRONAGE
  - INCREASES . . . . . TLV, SMALL AIRCRAFT, BUSES
  - DECREASES . . . . . AUTO
- NET REVENUES
  - HIGHER . . . . . TLV (VS. RAIL)
  - MIXED . . . . . AIR
  - LOWER . . . . . BUS
- ENERGY CONSUMPTION
  - LOWER PER PASSENGER-MILE
  - MIXED RESULTS IN TOTAL
- TRAFFIC SAFETY
  - LITTLE CHANGE

6
THE WORKSHOP

A key feature of the project was a Workshop at the midpoint of the study to review intermediate results and to identify and debate issues and impacts related to future transportation alternatives. Hershey, Pennsylvania, was the site of the Workshop during the week of September 7, 1975.

The Workshop was attended by the project team and 40 invited study participants, who represent a variety of interests, including technology, transportation policy, economics and finance, consumer representation, environmental concerns, resource consumption, and transportation industry management. Participants were selected early in the project and they contributed to the study by reviewing draft reports.

The Workshop was conducted primarily in small working groups termed "assigned panels." There were four such panels; they met several times during the week and followed generally parallel lines of inquiry. The membership of the assigned panels had been established before the Workshop by the project team to include a variety of viewpoints in each group. Early panel sessions focused on a review and critique of study scenarios, but most of the time was devoted to impact assessment. Each panel prepared a report of their deliberations.

Time was also allotted at the Workshop for "special topic sessions." Potential topics were suggested by study participants and sign-up sheets were used to gauge interest in holding a session. In each case where sufficient interest developed, two or three hours was devoted to a small group discussion. Topics included:

- The role of government in research and technology
- Transportation for the disadvantaged
- Changes in transportation regulation
- Energy options
- Access / egress / terminals / intermodal transfer

Papers describing the sessions are included in the *Workshop Proceedings*, Volume 5.

Major themes that emerged during the Workshop are presented here, together with samples of panel results.

MAJOR WORKSHOP THEMES

Capital May Be Scarce

A dominant issue at the Workshop relates to the availability of funds for future intercity transportation system development. Many participants anticipate that capital – both public and private – will be scarce. Further, much of that which is available will be devoted to such needs as the development of energy resources. Capital scarcity was seen to be a particularly formidable impediment to the introduction of new large-scale technologies but concerns are also noted on the availability of funds for maintenance and incremental improvement of existing intercity systems.

There is need, however, to continue transportation research and technology development activities on new systems. Institutional arrangements and funding mechanisms are needed to enable long-range technology explorations so these new systems can be ready for implementation when conditions are favorable.

Automobiles Will Continue as a Dominant Intercity Mode

Considerable attention was directed to the future of the private automobile. A near-unanimous view is that the mobility and privacy provided by autos will maintain the mode as a principal means of intercity travel. In response to high energy costs, a continuing and perhaps accelerating trend toward smaller, lighter vehicles with improved technology to reduce fuel consumption may occur. Coupled to this trend are uncertainties on future new car prices and sales levels – improved technology autos may be expensive and there may be greater emphasis on long-lived vehicles. A number of potential impacts on the auto industry could result from these conditions, including impacts on manufacturers (retooling), suppliers (new lightweight materials), and labor. There are also safety considerations related to small autos operating in the proximity of trucks and buses.

Intercity Bus Service is Attractive

Numerous positive impacts were cited for intercity buses. Energy efficiency is high, and the mode is capable of providing mobility to most segments of society – particularly the less-affluent. The incremental and flexible nature of bus service also makes it adaptable to a variety of possible future settings. Currently, there is need for better integration of bus services with those of other intercity (and urban) modes. More attractive and better located terminals are viewed as a means of gaining broader public acceptance of bus travel. Wider vehicles might also increase the appeal of bus service. Beyond these service, equipment, and facilities improvements, there may be more basic social reasons why travelers tend not to use intercity buses.

Air Service Is Likely To Improve Incrementally

Conventional aircraft service is anticipated to retain its role as the dominant public mode for longer-distance intercity travel. There may be less first-class service and more charter flights as the percentage of nonbusiness travelers increases. Some participants believe that less economic regulation might lead to fewer but more profitable carriers; others disagree.

The infrastructure for air service is viewed as already in place to a large extent. Incremental improvements to aircraft are foreseen as a continuation of existing trends although sources of capital for fleet replacement need to be identified. For positive impact, the emphasis in aircraft improvements should be to allow for increased operating efficiency and improved environmental impacts (e.g., better

EXAMPLES OF IMPACTS IDENTIFIED BY THE PANELS

Improved Conventional Aircraft. To achieve lighter-weight aircraft via epoxy/fibre composites will cause employment shifts. Epoxy makers benefit at the expense of aluminum makers.

Manufacture and use of composite materials may cause concerns about leakage into the environment in unexpected ways (e.g., stability in ultraviolet light).

Inexpensive air service might encourage nucleated cities within the range of a larger-hub city, permitting more choice of diversity in life-styles, but bringing the disbenefits of noise. With cheap flights, travelers who now exhibit behavior problems on other modes might shift to the air mode.

Tracked Levitated Vehicles. TLV might be used to channel land use development. Labor effects of the TLV are important; TLV automation might increase labor productivity, but other modes may be put out of work.

The energy consumption of TLV is comparable to aircraft, but TLV benefits by using centrally generated electricity. Pollution control would be easier.

TLV may be opposed out of fear that it will be noisy. The population along the right-of-way might oppose it because they fear accidents.

fuel consumption, less noise) rather than higher speeds. As composite materials are used to achieve lighter-weight aircraft, public concerns may arise about new compounds being released into the environment in unexpected ways.

The SST was one type of advanced air technology considered. There is doubt that noise (sonic boom) and environmental obstacles (upper-atmosphere pollution) can be overcome during this century. Introduction of the SST would serve national and foreign policy interests, but establishing sources of capital for development and implementation will be difficult.

Future of Rail Passenger Service Is Uncertain

Diverse views emerged at the Workshop on the future prospects and impacts of intercity rail service. One view holds that the transportation services provided by long-haul rail could be adequately handled by other modes and that a heavily subsidized mode should not compete with profit-seeking companies. Others hold that the service is in transition and has not yet had an opportunity to demonstrate its improved capabilities and attractiveness to travelers. In short-haul, high-density travel markets, the prospects for improved passenger train (IPT) service appear good, although it was noted that public and political pressures could expand the service to unprofitable markets. Extensive upgrading to track will be required to implement IPT, and studies are needed to determine the impacts that fast passenger trains would have on rail freight service.

In general, participants had misgivings about more exotic forms of high-speed ground systems such as tracked levitated vehicles (TLV). Their high capital cost and suitability for only a limited number of very dense travel markets are viewed as the basis for severe institutional as well as economic problems. Also cited were difficulties in obtaining right-of-way because of noise and safety concerns, political resistance generated by advocates of competing modes, and the need to overcome government jurisdictional problems.

Are Electric Highways on the Horizon?

A set of advanced technologies that provoked much discussion are electric-powered automobiles and electric-automated highways. In general, the prospects for these relatively undefined technologies appear to depend on the rate of development and eventual price of nuclear power generation; battery-powered automobiles for intercity travel are not judged likely because of range limitations. A critical unknown is the extent of overall (or petroleum) energy savings, if any, afforded by electric highways. Much discussion centered on the means by which vehicles would receive power from an electrified highway and uncertainties regarding the effects of such a system — primarily, traffic safety and the potentially harmful public health effects of strong electric and magnetic fields created by the system. Start-up problems for electric highways are envisioned. Potential users would be reluctant to equip their vehicles if available routes were limited; at the same time, expansion of routes might depend on demonstrated demand. Also, existing anti-trust laws might make necessary standardization of vehicles difficult. Several potential impacts that might occur with automated highways were identified, including the need for and impacts of traveler entertainment en route and the possibility of poor driver performance (e.g., speeding) upon leaving the automated system and reverting to manual control.

Access Can Be Improved

Many participants took the position that improvements in access and terminals can lead to substantially better intercity transportation service and would not require the massive capital outlays associated with new line-haul technologies. Noted in this regard were regulations in some locations that prohibit jitney services or service to airports by intercity buses. The diversity of existing problems among cities suggests that solutions might best be formulated on a case-by-case basis. Integrated multimodal terminals are cited as a goal and a decision is needed on what level of government should take a lead role in implementing the concept. One consumer viewpoint holds that there is a pressing need for door-to-door public intercity service, to create mobility for that large segment of the public which does not have access to an automobile.

Travelers Need More Information on Available Services

Better consumer information would enable travelers to use present and future intercity modes more effectively. In trip planning, it is currently difficult to identify all available travel options (both line-haul and access/egress) in terms of travel time and cost. Unresolved is the problem of providing full information without creating such complexity as to defeat the purpose. Also uncertain is whether carriers or a government agency should develop and operate the information system(s).

Steps should also be taken to provide better information to travelers while en route. More complete and more standardized displays of travel information are needed in air, bus, and rail terminals.

MAJOR WORKSHOP THEMES

EXTRACT FROM ONE PANEL'S IMPACT ASSESSMENT

IMPACTS OF IMPROVED PASSENGER TRAINS (IPT) AND SUPERSONIC AIRCRAFT (SST)

	Relative Degree of Impact (Scale of -3 to +3)[a]	
	IPT	SST
Secondary economic effects	1.25	0.00
Pollution (noise, air, and other)	1.33	-2.33
Regional development	0.33	0.08
Personal mobility	1.08	0.67
Energy and resource consumption	1.33	-2.83
Life-style	0.50	0.42
Political roles and conflicts	0.92	-2.92
Technology supply system	2.08	-0.92
Costs, revenues, and subsidies	-0.58	-2.42
Labor	1.08	0.08

a. Positive numbers indicate favorable impacts; negative, unfavorable.

Labor Issues Must Be Considered

Comments about varying aspects of the "labor issue" arose repeatedly during the Workshop. One basic concern relates to labor productivity: changes in the work ethic may cause a decrease in future productivity. This might argue for increased automation of transportation systems. On the other hand, it is suggested that technologies which are purposely labor-intensive might be adopted in order to create jobs. At a minimum, consideration should be given to retraining and employing people in labor and management who are displaced when obsolete transportation services are discontinued.

Government Roles Were Debated

Government roles in intercity transportation were another recurring theme of discussion. Differing viewpoints on federal government involvement in basic research and technology development (R&T) were expressed at a special topic session. While the government has a role in R&T, it is doubtful whether this role should extend to specific product development.

In the area of regulation, it was generally acknowledged that government regulatory agencies can be formidable barriers to some forms of technological innovation aimed at operational efficiencies or service improvements. However, it was argued that deregulation (the prospects for which are uncertain) might also negatively impact the implementation of new public transportation technologies. Extensive discussion took place on the prospects for government ownership of intercity modes and resulting consequences. Here, a distinction was made between full nationalization, which might lead to inefficiencies, and national corporations operating to a budget. Few arguments in favor of nationalization surfaced, but it was generally agreed that the prospect of capital scarcity increases the likelihood of government ownership for the rail and air modes.

ANOTHER PANEL'S ASSESSMENT OF FACTORS AFFECTING IMPLEMENTATION

Technology	Significant Factors Enhancing Chances of Implementation	Significant Factors Reducing Chances of Implementation
SST	Federal subsidies National and foreign policy interests	Restricted venture capital Increase in energy prices Government policy contradictions Equity more important than efficiency
TLV	Good system interfaces Transport industry nationalized Federal subsidies	Restricted venture capital Institutional inertia Continued jurisdictional issues
Improved conventional aircraft (CTOL)	Great increase in leisure National and foreign policy interests	Dramatic increase in discount rates
Improved auto	User attitudes and habits unchanged Increase in leisure Energy price increases	

7
IMPACT ASSESSMENT

The impact assessment task described consequences that might occur if certain technological developments take place in intercity transportation. These consequences are broad ranging, and include economic, environmental, social, institutional, energy-related, and transportation service implications. The possible consequences were traced through direct (primary) impacts to indirect (secondary, tertiary, etc.) impacts by fashioning chains of consequences.

The consequences that result are not predictions. The technological innovations considered may or may not happen, and if they do, the impacts described will not necessarily occur. The primary purpose of this analysis was to expand awareness of the possible implications of technologies in order to suggest further lines of inquiry on ameliorating negative impacts and enhancing positive impacts.

Some of the findings of the impact assessment are briefly illustrated here.

Identification of Impacts

The assessment of possible impacts of future intercity transportation technologies was undertaken through a systematic analysis approached from several directions. These directions are reflected in the following questions that were asked concerning the impacts of transportation developments.

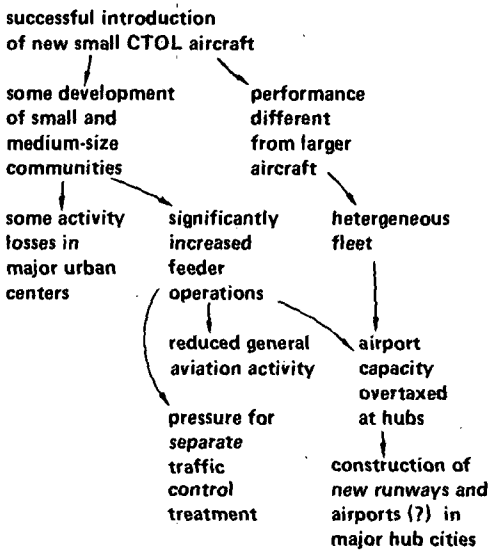
- How does the impact affect the development and use of economic, natural, and human resources; the the nature of the environment and settlement patterns; the life-styles, values, and well-being of individuals; and the evolution and behavior of political, social, and economic institutions?
- When does the impact occur in the life cycle of the technology? Is it during its invention, promotion, and development; its implementation; its operation; or its revision, replacement, or abandonment?
- How does the strength of the impact change with time?
- Under what political, economic, and social conditions and physical settings is the impact felt most strongly, and do changes in background conditions affect the nature of the impact? How might the impact change with changes in the conditions and setting in which it occurs?
- What are likely to be society's responses to the impact and how might these responses change the nature of the impact and give rise to additional indirect impacts?

These questions were used to trace the chains of consequence associated with technology development options.

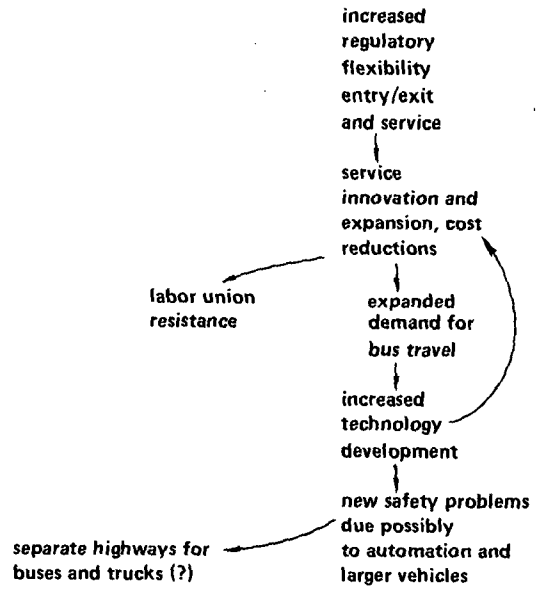
Small CTOL Aircraft

Successful introduction of new small CTOL aircraft would be expected to enhance the position of small- and medium-size communities in competing against the larger urban centers for economic development. The magnitude of such enhancement is relatively minor, however, compared to other economic and political factors affecting business and population decentralization, such as tax policies, housing and social service policies, and environmental controls.

Major expansion and improvement of commercial air transportation in low-density markets might be expected to reduce the utilization of personal and corporate general aviation aircraft to some extent. The tendency to cause a major slowdown or even a reversal of general aviation activity would be minimized under a strong economic growth scenario, in which the convenience, flexibility, and freedom offered by privately owned aircraft would be valued most highly against their cost.



Extensive feeder services provided by a new generation of small commercial aircraft could have a significant impact upon crowded hub airports where feeder and line-haul links join. Pressure could mount for separate treatment in the air traffic control system of feeder operations, particularly if such aircraft have significantly different operating speeds and maneuverability than the larger aircraft. Unless separate runways can be provided, expanded feeder services could seriously tax existing airport "airside" capacities. Although construction of new airports in major metropolitan areas would help, assuming financial and political feasibility, the distribution of traffic among metropolitan airports is not likely to be "rational" enough to completely solve this problem.



Intercity Bus

Improved intercity bus service is a particularly effective means to provide increased mobility and economic opportunity to the disadvantaged. Bus systems provide essential links between rural communities and various health and social services; hence, their improvement would be expected to encourage population dispersal, particularly if employment opportunities continue to move away from large cities.

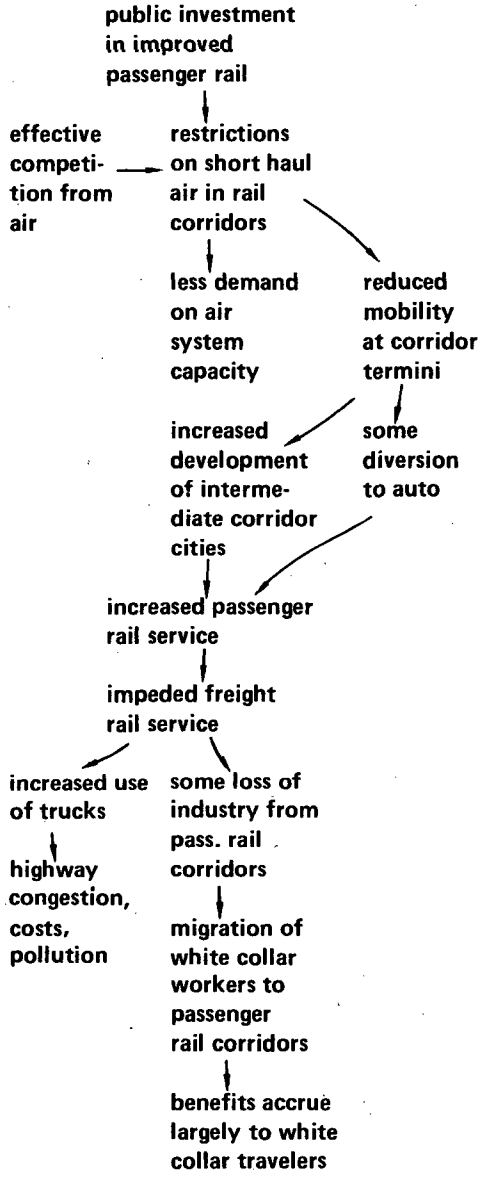
Major near-term improvements in intercity bus transportation would likely be dependent upon regulatory agency willingness to loosen restrictions on market entry/exit and service. Such willingness could encourage innovations such as more express service, better connections with other intercity modes and with urban public transport, and introduction of different classes of service (e.g., widebodies).

Articulated buses might be introduced to achieve some economies of scale by reducing labor costs. Vigorous growth in intercity bus service might help to establish a suitably sized vehicle fleet for early experimentation with automated highways in a few densely traveled intercity corridors. If such experiments are successful, a major opportunity would be created for additional increases in bus labor productivity, for example, using a highway-train of temporarily linked buses with a single driver. Such innovations are not without problems, of course, such as the possible resistance of organized labor, safety considerations (perhaps requiring separate rights-of-way for highway-trains of buses and trucks), and the need for suitably powerful (perhaps detachable) propulsion systems to allow efficient tandem operation and to help ameliorate potential noise impacts.

Improved Passenger Trains

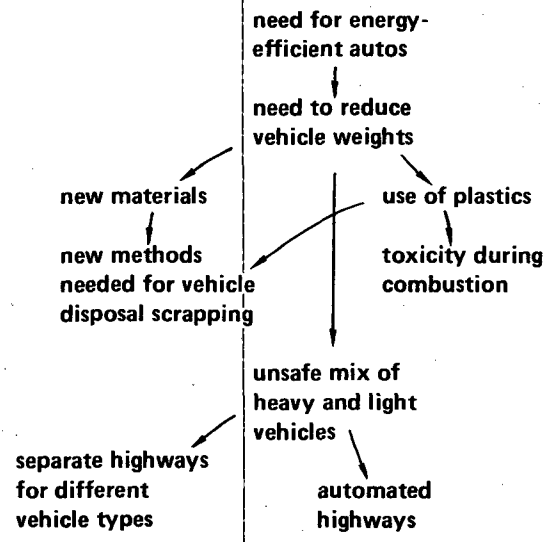
Under a scenario of strong government involvement in intercity transportation, attempts to promote rail travel might lead to public restrictions on short-haul air service in corridors where heavy public investment in rail provides good alternative service. In this situation, some former air travelers would probably switch to rail as their next best option with others, perhaps the majority, switching to private automobiles. Demands on the air traffic control system and on airport capacity would be reduced by these restrictions. Travelers would suffer some loss of mobility, perhaps significant losses in certain cases. Economic and population growth at intermediate stops along the improved rail corridor could be significant, further stimulating rail use throughout the corridor.

Expanded and improved intercity passenger rail service, operating at speeds up to 120 mph might interfere with rail freight operations to the detriment of both the rail freight industry and rail freight customers in affected corridors. Some departure of rail-dependent industry from busy passenger rail corridors might result; or such industries might make greater use of trucking, increasing traffic, maintenance, and environmental problems on corridor highways. Over the long term, the attraction of passenger rail for business travel up to about 250 miles would be expected to increase the proportion of white collar workers that reside in and benefit from the improved passenger rail corridor. This relocation effect would be greatest in scenarios with high-density housing growth and high highway-travel costs.



Lightweight Automobiles

Emphasis on energy efficiency may lead to long-term efforts to reduce automobile weight, raising the need for suitable lightweight materials and components. If plastics are used extensively, questions arise concerning: the price stability and availability of petrochemicals for their manufacture, the availability of methods for reducing old cars to marketable scrap, and the toxicity of fumes released by plastics during auto combustion due to scrapping and accidents. Increased safety problems may be anticipated in collisions of light vehicles with the older heavier autos, and with trucks and buses. This suggests the possibility of separate highways for light vehicles, which would be achieved, of course, only with large implementation costs and significant environmental impacts. A possibly more economical alternative to separate highways is the automation of existing highways to increase safety and achieve other benefits. However, the safety problems that could occur during the transition to automation are themselves potentially serious enough to warrant considerable attention.



8
RECOMMENDATIONS

One of the products desired of this study was a set of recommendations on further research and analysis tasks pertaining to the impacts of future intercity transportation technologies. Reports of this study's tasks—Volumes 2 through 6—contain many explicit and implicit recommendations of this kind. The contractor study team chose to highlight a limited number of recommendation topics rather than compile an exhaustive list of the many possible additional study efforts that are suggested in the project's documentation.

The selected recommendations on further research and analysis tasks are summarized in this chapter and described more fully in Volume 7.

In the judgment of the study team, the highlighted recommendations relate to *significant* issues or impacts, with important implications for the quality of future intercity transportation, and have *high leverage*, that is, they are believed to offer promising avenues for substantially improving intercity transportation. Many of the highlighted recommendations apply to the future supply of intercity transportation services, categorized by mode. Others pertain to broad issues in intercity transportation—e.g., finance, regulation, traveler values—that cut across modes.

In accordance with study guidance, the recommendations describe what should be done but generally do not identify who should sponsor and/or perform the work, except in those instances where it is central to the recommendation. Also, neither priorities for the recommendations nor detailed work statements were requested by the study's sponsors.

Given the diversity of opinion uncovered during the study on, for example, what constitute desirable and undesirable features of future intercity services, it is clear that the study team's selection of recommendations represents only one of several "cuts" at the problem. A sampling of other possible recommendations on transportation research and technology tasks is given in Volume 7. That volume also contains study team recommendations regarding the process of technology assessment.

INTERCITY AUTOMOBILE TRANSPORTATION

Recommended Efforts

A greatly expanded program of research and technology development for propulsion systems and vehicle design with the objective of improving fuel-efficient and nonpolluting alternatives to the present automobile. A key to the expanded program is careful coordination of publicly supported efforts and automobile manufacturers' efforts. Public efforts should emphasize high-risk research and monitoring the rate of technological improvements in energy efficiency in order to advise control agencies when more exacting pollution standards and fuel-economy standards should be applied.

A technology assessment focused specifically on impending technological and institutional changes to the automobile. Immediate concerns include the safety impacts of changing fleet size and performance mix, income redistribution effects of possible changes in the buying patterns of new cars versus old, and upcoming changes in vehicles and their fueling methods to meet environmental standards. Longer-range concerns include the impacts of alternate automobile engine technologies on the industry, labor, and the economy.

Rationale

Patronage analyses conducted in this study indicate that the auto will continue to be the dominant mode of intercity travel in a variety of possible settings to the year 2000. The dominance of auto travel arises from a variety of factors, including low perceived cost and great flexibility and convenience of service relative to public modes.

The auto-highway system constitutes both a major "investment"—economic, institutional, and social—and a principal "leverage point" for effecting desirable changes in the impacts of intercity transportation.

TRANSPORTATION ENERGY CONSUMPTION BY MODE

Mode	% of Total Transportation Consumption
Auto—Intercity	29.4%
Auto—Urban	32.0
Air	7.6
Bus	0.6
Rail	3.4
Truck	18.0
All Other	9.0
Total	100.0%

COMPARATIVE ENERGY EFFICIENCY

Mode[a]	Thousands of Btu per Passenger-Mile
Auto (full-sized)	2.3
Bus (diesel)	0.7
Rail (metroliner)	1.0
Air (DC-9 at 500 miles)	4.2

a. 60% load factor assumed for all modes.

Source: Volume 3

INTERCITY BUSES

Recommended Efforts

A program to identify and test means of improving intercity bus service. The program should explore possible vehicle changes such as wider buses. A series of case studies should expand on existing research knowledge to improve bus transportation, such as seeking innovative ways to improve bus stations and to provide better integration of bus services with those of other modes. In direct support of these studies, an evaluation is needed of public attitudes and user choice factors influencing bus patronage.

A study to appraise the effects of federal and state regulatory policies on bus operations. This effort should identify and evaluate impacts that would result from changes in policies, and explore the economics of and financial mechanisms for increasing bus service to small towns and rural areas.

Rationale

To the extent that intercity bus service can be improved to attract increased ridership, there is potential for significant benefits. Foremost among these potentials are reduced energy consumption for intercity travel and increased mobility to residents of small towns and rural areas and others who travel on low-density routes.

AIRCRAFT AND AIR SERVICE

Recommended Efforts

Aircraft research and technology emphasizing developments leading to reduced cost, fuel consumption, and noise. Among these are improved airfoils, composite materials (including demonstration of use of large composite structures), propulsion improvements, reduction of other (nonengine) sources of noise (i.e., aerodynamic noise), and active controls.

A study of mechanisms for introducing new aircraft technology into commercial use. The study should include an appraisal of government financial, tax, and regulatory policies to encourage more rapid implementation. For example, an assessment should be undertaken on the current program to develop quiet aircraft engines. The study should evaluate not only environmental impacts on a national scale but also the economic impact on engine manufacturers and financial constraints that the airlines might face in attempting to acquire the technology on a priority basis.

Systems analyses of changes in aircraft scheduling, routing, and operations. The aim of these studies should be to reduce costs and fuel consumption while maintaining acceptable service levels. A range of future aircraft sizes and technologies, as well as the impact of changes in industry regulations should be considered.

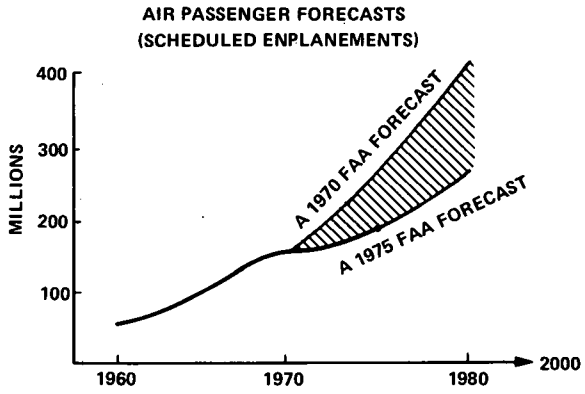
Expanded scope for ongoing STOL aircraft technology efforts to include short runway aircraft (SRA) systems. The SRA systems would use longer (3,000- to 5,000-foot) runways than STOL at existing or new satellite airports. The availability of satellite airport sites—closer to larger population centers than existing major airports—requires investigation.

Rationale

Conventional air service is expected to continue in the future as the dominant public mode for long-distance travel. The obvious advantage of air service relative to its major competitor, the automobile, is speed of travel. Negative characteristics of present services include fares and energy consumption at the high end of the intercity transportation spectrum and noise in the vicinity of airports.

Commercial aviation has had limited success in providing high-quality service at low cost in short-haul markets with low travel densities. Positive impacts on small communities could be expected as the result of economic breakthroughs in the development costs and operating costs of small (10- to 20-seat) aircraft or routing and scheduling innovations for larger aircraft.

The potential ground access savings of an SRA system would benefit air travelers in high density travel corridors. An SRA system might also relieve congestion at long-haul airports. Aircraft energy consumption and operating costs decrease significantly as design runway length is increased from 2,000 to 5,000 feet. The future availability of either STOL- or SRA-length runways at desirable sites is uncertain.



AIRPORT AND AIR TRAFFIC CONTROL CAPACITY

Recommended Efforts

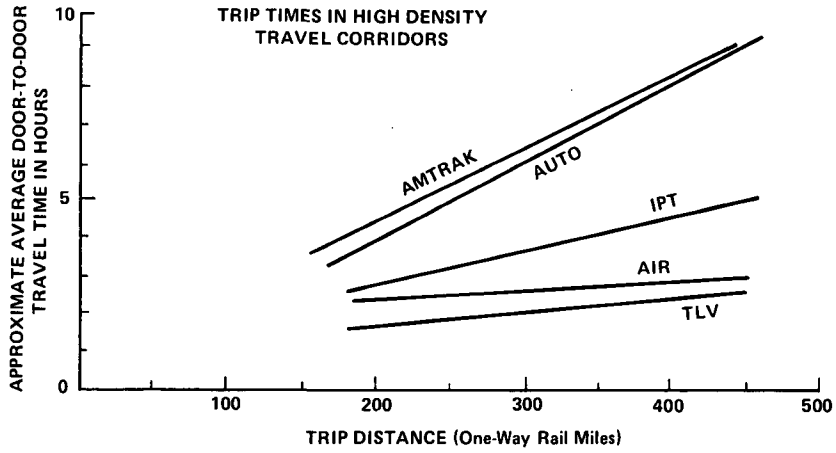
A study to resolve uncertainties on features of future generations of the ATC system. This study should be based on a comprehensive review of the effectiveness and costs of components of the Upgraded Third Generation Air Traffic Control (ATC) System.

A program of airport landside research, closely coordinated with ongoing airside work. The objective of the program would be to develop planning methodology and guidelines for airport landside improvements. Case studies of a number of representative airports should be undertaken, evaluating passenger and baggage processing improvements, both in capacity and efficiency.

Rationale

In spite of a trend toward lower forecasts of future air traffic growth, substantial increases in passenger traffic and in aircraft operations are still foreseen, thus creating the continued need for more airport and air traffic control capacity. Uncertainty exists on ATC improvements that should occur beyond those encompassed by the Upgraded Third Generation ATC System.

While substantial research studies on alternatives for airfield improvements have been conducted under FAA auspices, comparatively little effort has been devoted to landside research.



Source: Volume 4 Scenario Analysis

RAIL (Fixed Guideway) SYSTEMS

Recommended Efforts

An analysis of the benefits and costs of existing AMTRAK services. Data need to be analyzed on a systemwide as well as route-by-route basis, in relation to other modes, to assist in decision-making on changes to the AMTRAK route structure and the desirability of continuing government subsidy.

Technology and systems evaluations of improved passenger train service. Efforts should focus on ways to implement service as soon as practical on appropriate routes to capture potential energy savings. Questions related to noise, safety, and interactions with freight service need to be addressed in specific rail corridors.

Tracked levitated vehicle research studies to address currently perceived negative impacts of the technology. These concerns include high guideway construction costs, noise, and safety. Vehicle and guideway technology studies for TLV are of a high-risk nature but component research should be undertaken to understand and perhaps resolve systems impact problems.

Rationale

Although a final evaluation of AMTRAK costs, performance, and patronage may be premature because improvement programs are now under way, the question of continued government subsidies for passenger rail service is of major importance.

For travel corridors examined in this study (high-density markets of less than 500 miles), high-speed IPT rail service appears attractive on the basis of several positive impacts. Door-to-door trip times and fares for IPT should compare favorably with those for air service while energy consumption is lower.

High-technology, tracked levitated vehicle systems are now looked on with serious misgivings of a financial, institutional, behavioral, and environmental nature. High investment cost coupled with a very limited number of potential geographic applications raises doubts on political viability.

ELECTRIC/AUTOMATED HIGHWAYS

Recommended Efforts

A technical study to identify and evaluate electric/automated highway system options. The study should develop data on technical and economic feasibility for alternative propulsion and control subsystems, and on the power generation and transmission implications of widespread implementation. Development might be pursued to the stage of small-scale "laboratory" demonstrations of performance.

A systems study of electric/automated highways to explore options in detail, after required technical data have been assembled. Considerations should include potential markets for intercity and urban travel, alternative implementation time frames, and energy and environmental impacts. Other important questions relate to traffic safety (particularly during implementation), system reliability, regional development implications, effects on private sector equipment and vehicle suppliers, and effects on other modes. Costs and benefits should be identified for both potential users and nonusers of an automated highway system.

Rationale

Electric highways offer the possibility of dramatic reductions in fossil fuel energy consumption for intercity transportation to the extent that nuclear or other nonfossil electrical-generating capacity is available in the future.

While the technology may not be implementable during this century, it seems to pass the critical tests of political constituency, incrementalism, and significant private-sector involvement.

ACCESS/EGRESS AND INTERMODAL TRANSFER

Recommended Effort

A continuing program of study and experimentation to improve access/egress and intermodal transfer for all intercity modes. The program should include study of inexpensive changes to urban public transport services and vehicles to help meet intercity traveler requirements, terminal design and location options, and analysis of effective means to disseminate travel information. Reviews of recent studies of multimodal terminals should be undertaken with a view of identifying the major roadblocks to successful implementation. For the most part, this program should be case-specific (and conducted locally in cooperation with state and local governments and private operators), although a search for problem commonalities among different urban areas should be emphasized.

Rationale

Solutions to access/egress problems are elusive. Many organizations are engaged in the provision and regulation of access/egress services and gaps in service or suboptimization can result. There appear to be few commonalities among access/egress and intermodal transfer problems in different locations. Each case is heavily influenced by local history, geography, and settlement patterns, as well as regulatory precedents.

To concentrate what would otherwise be diffuse access/egress trips in an urban area and to facilitate intermodal transfer (e.g., rail to bus), the multimodal terminal concept has appeal.

ACCESS, EGRESS, AND TERMINAL TIME AS A PERCENT OF DOOR-TO-DOOR TRAVEL TIME[a]

Trip Distance[b]	Bus and Rail	Air[c]
150	25%	75%
300	15	65
500	6	55
1,000	4	45

a. Approximate, based on Volume 4 scenario analysis.
b. Miles, one-way.
c. Nonstop flights are assumed.

TRAVELER VALUES AND PREFERENCES

Recommended Efforts

Studies to develop improved information on the preferences of various types of intercity travelers, encompassing all modes. Particular emphasis should be placed on the relative importance of perceived cost, travel time, comfort, and convenience as influences on choice of mode for different travelers and types of trip. The project should include development of more comprehensive theories of choice and preference for travelers, supported by a small number of carefully designed, in-depth interviews with intercity travelers in selected categories. Choice models including variables, such as those suggested above, should be postulated and calibrated to aid in intercity transportation planning.

A related study to investigate the feasibility of an expanded and more detailed data base on intercity travel volumes. For example, the feasibility of publishing origin-destination travel data for rail and bus modes should be investigated, and survey procedures for the development of automobile travel data on a continuing basis should be developed.

Rationale

An improved and more quantitative understanding of propensity to travel and traveler choice among competing modes is essential to support decisions regarding future intercity transportation research, investments, and service improvements. A starting point for this advance in knowledge is a better understanding of current traveler values and preferences — more comprehensive and higher-quality data are needed.

REGULATORY CONTROLS

Recommended Effort

A study to develop and apply methods of assessing possible regulatory changes and their impacts. Improved techniques are needed to analyze the effects of alternative economic, environmental, and safety regulations on levels of intercity service, transport industry structure, and technology development and implementation. The objective of the effort should be to provide guidance on regulatory actions and R&T program priorities. The study should encompass all major modes of intercity transportation for both passengers and freight.

Rationale

Regulation has played, and will continue to play, an important role in both the development and control of transportation infrastructure and in the organization and operation of firms providing transportation services. Future changes in regulation will act as a barrier or spur to such factors as technological innovation, the speed of implementing new services, and the financial viability of transportation systems.

While several alternative "regulatory futures" and possible effects have been identified in this study, a most-likely or desirable path of change has not been identified.

INSTITUTIONAL IMPACTS

Recommended Effort

A program to better identify and evaluate institutional forces that may affect the implementation and operation of new intercity transportation technologies. A method is needed (such as has been developed for preparation of environmental impact statements) for tracing the potential events that would have to take place in the process of technology delivery, for identifying the institutions involved and their roles, and for highlighting critical institutional actions.

A detailed review should be undertaken of institutional forces that have had major impact on past transport technology programs (e.g., the airport and airway development program, development of the AMTRAK system). Both the positive and negative institutional forces should be identified and examined. Also, the economic, social, and environmental conditions and forces that existed over the time of planning and decision-making should be described and assessed to determine how they affected decisions.

Currently proposed technology programs should be appraised to identify institutional forces that may influence their ultimate delivery. Attention should be given to both major "hardware" innovations such as automated control of automobiles and major "software" innovations such as ticketing for door-to-door intercity common-carrier transportation.

Rationale

Public and private institutions combine in different ways to establish the services provided by intercity transportation systems, giving rise to institutional arrangements that are resistant to change.

Institutional forces, rather than a lack of new technology options, may constrain the introduction of new intercity transportation systems — especially those that would introduce major service changes.

ENERGY AND MATERIALS CONSIDERATIONS

Recommended Efforts

A program of research and technology development among modes to improve the energy efficiency of all intercity transportation vehicles. The potential results of current fuel conservation programs should be evaluated with respect to environmental, economic, and financial impacts. The possibility of federal actions to assist in speeding the implementation of fuel-efficient technologies should be investigated.

Continuing research on new materials for transportation vehicles with increased consideration given to materials research for ground transportation. Techniques for disposal and recycling of materials should be an integral concern of these investigations. Research and technology development on improving the economics of scrap-metal recycling are sufficiently important to warrant continued significant effort.

Rationale

National energy policy will provide significant impetus to improve the fuel economy of intercity transportation vehicles. In the unlikely event that ways are not found to significantly improve transportation fuel economy, it will be difficult to introduce improved intercity services (i.e., higher speeds, more frequent service) that require more energy than is consumed at present.

Development of light but crashworthy highway vehicles at reasonable cost would be stimulated by materials development; a variety of aircraft efficiency and performance improvements are also dependent on lightweight composite materials. Important issues related to future materials widely used in transportation vehicles are the methods of disposal of worn-out vehicles and the potential for recycling scrap materials.

TRANSPORTATION ENERGY CONSUMPTION IN RELATION TO TOTAL DOMESTIC CONSUMPTION
(10^{15} BTU FOR 1970)

	Basic Energy Source		
Use	Petroleum	All Other[a]	Total
Transportation	16	--	16
Electric Power Generation	2	13	15
All Other Uses	12	29	41
Total	30	42	72

a. Natural gas, coal, hydroelectric, nuclear.

TRANSPORTATION FINANCE

Recommended Effort

A comprehensive study of funding requirements and sources for intercity transportation. The objective of the study would be to quantify short- and long-term financing problems in intercity transportation and to identify and evaluate funding mechanisms. The study should consider (1) public and private sources of funds and (2) transportation capital and operating/maintenance funding requirements. The evaluation of funding mechanisms should emphasize those that accommodate technology substitution, such as a combined transportation fund, and those that use public funds to stimulate private investment.

Rationale

Funding constraints will pose increasingly severe problems that must be solved before major improvements in intercity transportation systems can be made.

Recently, a number of studies have projected serious deficiencies in the overall supply of capital over the next 5 to 25 years. Private-sector investment in major intercity transportation system improvements is particularly vulnerable to a capital shortage because of high investment levels needed to maintain existing services.

To the extent that private venture capital is scarce, demands for government involvement in the financing of intercity transportation will increase. Public programs may be required to strike a balance not only across the majority of political subdivisions, as in the past, but also across influential interest groups defined along social or economic lines (the poor, aged, environmentalists, etc.). Legislation drawn along modal lines, such as highway, air, rail, or urban public transit programs, seems increasingly unable to meet these required distributional conditions.

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