in character, involving bus lines and air transportation. Intercity bus schedules operate into or through substantial numbers of airports. Examples are Logan International Airport, Boston, Massachusetts; O'Hare International Airport, Chicago, Illinois; Mitchell Field, Milwaukee, Wisconsin; and Stapleton International Airport, Denver, Colorado. Through ticketing is not, in general, provided in such situations, and intermodal schedule and fare information requires reference to the Official Bus Guide, the Official Airline Guide, and applicable bus tariffs. Furthermore, much travel involving both the bus and air modes necessarily involves some form of supplemental ground transportation between the air and bus terminals or stations -- a condition dictated by the fact that, due to airport space requirements, an air terminal must generally be located some distance from the central city.

Intermodal service involving local transit services is pervasive from one point of view and quite elusive from another. Located generally in the central city of most large communities and at important points in suburban places and in smaller communities, intercity bus stations and terminals are, for the most part, readily accessible from local transit services that may exist. However, use of such local transit services tends to be difficult for persons not familiar with routes, fare structure, and so on, as has been described here earlier. Taxicabs and private automobiles probably represent the remaining modes of significance. Both find comparatively ready accessibility to bus terminals and stations. In some cities automobile parking is not as convenient to such facilities as it might be. A broad problem in some cities is that the neighborhood locations of bus terminals and stations have deteriorated over the years, and they have, therefore, become less attractive to the traveling public.

Two principal questions remain: Why has not more been done? And what are likely development possibilities for the future? It should be noted that most governmental and other authorities and groups involved have expressed approval of intermodal concepts, at least in principle. The Congress in 1978 authorized a program of assistance for development of bus terminals in which the facilities would be primarily for intercity bus service and also for "coordinating such services with other modes of transportation." No funds have as yet been appropriated for this purpose.

The extensive and expensive Northeast Corridor Improvement Program, primarily for the benefit for Amtrak, includes funds for terminal acquisition and development in the corridor. However, despite repeated assertions by the Department of Transportation, the Federal Railroad Administration, and Amtrak recognizing the need for greater coordination between Amtrak and the intercity bus mode, most terminal development under the Carter program for assisting bus operations has been effectively ruled out by the Federal Railroad Administration.

With respect to Union Station in Washington, D.C., all of the development to date at this location has been directed to facilities for the benefit of Amtrak and local transit. Most proposals for future development also ignore intermodal aspects involving intercity bus.

Intermodal travel of one type or another is necessary for most intercity journeys. Travel to a teriminal or a station is generally required before an intercity trip can be commenced, whether the mode is bus, air, or rail. The principal exception is charter bus travel where members of a charter party are often picked up in their local neighborhoods.

In many instances, the individual traveler's choice of mode is limited. If the travel begins in a rural area or small community, intercity bus may be the only common carrier mode available for part or all of the trip, along with, possibly, a short, initial leg by automobile or, where it exists, some form of paratransit. At the end of the trip, the same requirement for local transportation often exists.

For travel from or to a large city, somewhat greater choice of intercity mode may exist where rail or air transport is available. The air mode is becoming increasingly expensive, as will the rail mode if any reasonable fraction of the cost of operating rail service is reflected in the cost of passenger tickets. For the local leg at the beginning or end of an intercity trip from or to a large community, local transit travel may be an option along with taxicab and private automobile. As a result of such considerations, there have been proposals for a comprehensive program of surface transportation centers for both large and medium-size communities to improve interface between local and intercity transport modes.

A problem often faced with intermodal terminals serving more than one intercity mode is that the terminal location may be optimum or required for one mode but may not meet the requirements of other modes. For trips on which more than one mode of transportation is available, such factors as comparative convenience, comfort, speed, and flexibility are important in modal selection for all or successive parts of the travel involved.

The popularity of the automobile rests primarily on its flexibility and comparative economy where the travel party consists of more than one or two persons. Air travel is unmatched for speed, at least terminal to terminal, and rail travel enjoys comforts and amenities stemming from space and weight equipment relative to passenger seating capacity. The intercity bus has a number of advantages, including more flexibility than either air or rail, comparative economy, and schedule speed often equal to or exceeding rail, particularly for short and mid-length trips.

To the extent that travelers can avail themselves of a variety of such attributes on successive segments of trips without undue effort, expense, or time in transfers, intermodal travel is obviously advantageous. As already noted, some steps have been taken to facilitate such intermodal movements, and developments for the foreseeable future appear likely to follow the same general patterns, probably on an accelerated basis as the cost of travel increases. Comparative fuel efficiencies will also be a factor.

## OPENING COMMENTS

Robert L. Bowles, U.S. Department of Energy

In this discussion I will review and highlight some approaches to evaluating and comparing the energy intensities of various transportation modes. Some comments will also be offered on the perspective with which energy intensity information should be used, and the energy conservation potential afforded by intermodal travel.

Energy intensive values are useful tools in studying the energy-related behavior of a particular transportation mode and forecasting its future fuel requirements. These numbers are frequently employed as benchmarks to evaluate the energy conservation potential or performance of an improvement to a particular means of passenger travel.

Great care must be employed, however, when energy intensive values are used in an assessment of alternative intermodal transportation scenarios.

For example, one common method used is to determine the ratio of the total modal energy consumed to the total modal services produced. Thus, in such cases the energy intensive figures are describing only an average condition. Actual specific cases can vary significantly from such averages. It is also common for these calculations to fail to take into account the energy consumption used in the construction, maintenance, and repair of both the vehicles and the thoroughfare systems of a transportation mode.

Further, it must be noted that energy intensity represents only one criteria on which to base transportation planning or other decisions. Service needs cannot be ignored. For example, while it is true that air passenger service is the most energy intensive mode for intercity travel, few consumers would be willing to travel across the country by any other mode.

Another constraint on the utility of energy intensive factors is that only the "line haul" portion of the trip is typically considered and not the complete door-to-door trip. For an intermodal trip from Washington to New York, the energy consumed getting to and from the transportation terminals can represent about 20% of the total trip energy consumption. Terminal access and egress as well as metropolitan area congestion issues for specific cases can also dominate system planning and modal choice decisions.

There are two major parameters used to express the energy intensity of various intercity passenger transport modes. These are Btu's per passenger-mile and Btu's per seat-mile. Others, such as gallons per seat-mile and passenger-miles-per-gallon, can be calculated by simple mathematical manipulations.

The number of Btu's per passenger-mile takes into account the load factor achieved by a particular mode. This parameter thus represents the average energy required to transport a single passenger one mile via a particular transportation mode. The energy intensity of the automobile or aircraft is far greater than that of the bus or the rail modes.

Btu's per seat-mile represents the average energy required to transport a single passenger one mile considering 100% of all the seats on the vehicle are occupied. It is a useful measure for comparing the limits of energy conservation potential for various modes. On the basis of the Btu's per seat-mile, air travel is four to five times as energy intensive as either the bus or rail modes.

Hence, we see that energy intensive values are useful indicators of the energy conservation potential of operational changes to improve scheduling and thereby increase load factors. Technological improvements can also decrease the energy intensitiveness of a particular mode of travel. These improvements can be classified under the two generalized headings of evolutionary and revolutionary changes.

An evolutionary change occurs when a particular class of vehicles is progressively refined. These refinements of a vehicle usually yield a small percentage reduction in energy intensity. A few examples of such changes might be the dieselization of buses, the use of high-pressure, high-bypass turbofan engines on aircraft, and the introduction of electronic engine energy controls for automobiles. These improvements may also be implemented without major changes to existing vehicle or component designs.

A revolutionary change requires a breakthrough in which some new concept or technological development makes possible a new class of vehicle or major design modification. This type of improvement often has the potential for a major reduction in the energy intensity of the transportation mode if the use of the new vehicle significantly displaces less efficient vehicles in its class. Examples of revolutionary changes might be the magnetic levitation train, the Lear fan aircraft, and specialized automobiles, such as the electric car.

From an energy conservation point of view, it is indeed unfortunate that energy intensive numbers are not considered by consumers when choosing between alternative modes of travel. The criteria of cost, timeliness, and availability appear to be the major factors that influence the utilization of one mode over another. It then follows that one way to induce consumers to use a less energy intensive form of intercity travel is to improve the interrelated factors of timeliness and availability. Such an approach appears to be applicable to intermodal trips.

Recently, several excellent examples of this concept have been implemented that required relatively simple implementation. This concept has been alluded to earlier by several of the panel members. In several cases, bus schedules now provide immediate tie-in and follow-on service to some of the Amtrak schedules. The New York subway system provides combination subway-bus service to the JFK Airport. Additionally, as has also been alluded to, an Amtrak train station was recently opened at Baltimore-Washington International Airport, which provides rail service between the two cities.

These newly added intermodal services also provide excellent examples of ways to lessen the petroleum dependency of the passenger transportation system, since intercity rail and subways can be powered by electricity generated from non-petroleum energy sources.

I would like to conclude my remarks by postulating that future reductions in the energy intensity of passenger travel will almost probably occur at all levels; that is, through higher load factors, more efficient fuel-efficient operations and maintenance practices, and evolutionary and revolutionary technological improvements. Also, the multifaceted nature of the passenger transportation system possesses the capability for a rapid reduction in the total transportation energy and petroleum consumption. This is due to its inherent ability to absorb modal shifts to less energy intensive modes and non-petroleum modes during energy supply disruptions. However, the task remains for individuals, like those of us gathered here today, to effect such changes. Lastly, while door-to-door energy use for multimodal travel is not clearly understood, the improvements in availability and timeliness of bus and rail travel for intermodal trips clearly hold the potential to save petroleum by encouraging people to use less energy intensive vehicles both at the beginning and end of an intercity trip.

## FINAL SUMMARY AND CONCLUSIONS

The preceding pages have provided the opening comments made by the panel participants. These opening comments serve as an overview. To condense all of the discussion from the panel and audience into a few short statements is, perhaps, misleading; however, certain points did consistently emerge. These points are organized by the six conference session objectives.