BALANCE AND INNOVATION IN URBAN TRANSPORTATION

William F. Hamilton, II, General Research Corporation

Proponents of balance in urban transportation have won a major victory. For years they have argued that the increasing dominance of the automobile was unbalanced, that public transit should accordingly be revived, and that urban life would thereby be substantially improved. Now the federal government has taken heed and is readying a national program of transit revival backed by a major financial commitment. That balance has emerged as a political success seems natural enough: No one, after all, advocates imbalance. That balance will emerge as a practical success, however, achieving the benefits ascribed to it in a manner commensurate with its costs, is not nearly so clear. At present, balance is often so narrowly interpreted as to exclude significant innovation in urban transportation. Without innovation, balance consists simply of increased investment in conventional transit, and the capability of conventional transit to induce major improvements in the quality of urban life is obscure at best. This paper first reviews the national emphasis on balance and the role in it that innovation is currently accorded. Then it evaluates conventional and innovative systems through quantitative comparisons of their projected costs and benefits with the goals of the new federal transit program. Finally, it summarizes the case for emphasizing innovation in the national effort to balance transportation.

•THE federal government began subsidization of urban transit under the Housing Act of 1961. As the pilot program got under way in 1962, President Kennedy urged Congress toward a larger undertaking: "Our national welfare therefore requires the provision of good urban transportation, with the properly balanced use of private vehicles and modern mass transport to help shape as well as serve urban growth." Congress responded with the Mass Transportation Act of 1964 and its amendments, which provided increasing support of transit through the remainder of the decade. Resultant appropriations for federal transit subsidy during the 1960s are shown in Figure 1 (1).

The renaissance of urban transit, however, has not yet arrived. If anything, the national decline of transit fortunes has accelerated, as national operating incomes reported annually by the American Transit Association reveal (2). This decline is also shown in Figure 1; in recent years, the data suggest runaway deficits rather than renewed vitality.

Now, as a new decade begins, President Nixon has proposed and obtained a new transit program for improving urban transportation (3). The program does not, however, contemplate national changes in direction. Instead, it reasserts the need for balance and employs a major subsidy increase to attain it—$1 billion per year by 1975. The President said: "We must have a truly balanced system. Only when automobile transportation is complemented by adequate public transportation can we meet [future] needs. I propose that we provide ten billion dollars out of the general fund over a twelve year period to help in developing and improving public transportation in local communities."

The President specifically called for 95 percent of the $10 billion to be devoted to capital improvements in public transportation. With the addition of the usual local contributions, this is more than $14 billion, a sum not far from the $17.7 billion announced by the transit industry as its own appraisal of its capital needs for the coming decade

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(4). If increased investment were the sole criterion, the new program would surely be judged as a major step toward balanced transportation.

Something more, however, may be vital. As data shown in Figure 1 suggest, public transit in its present form does not attract adequate patronage. Accordingly, President Nixon also called for devoting 5 percent of the new transit program to "... research and technology efforts into new ways of making public transit an attractive choice for owners of private cars."

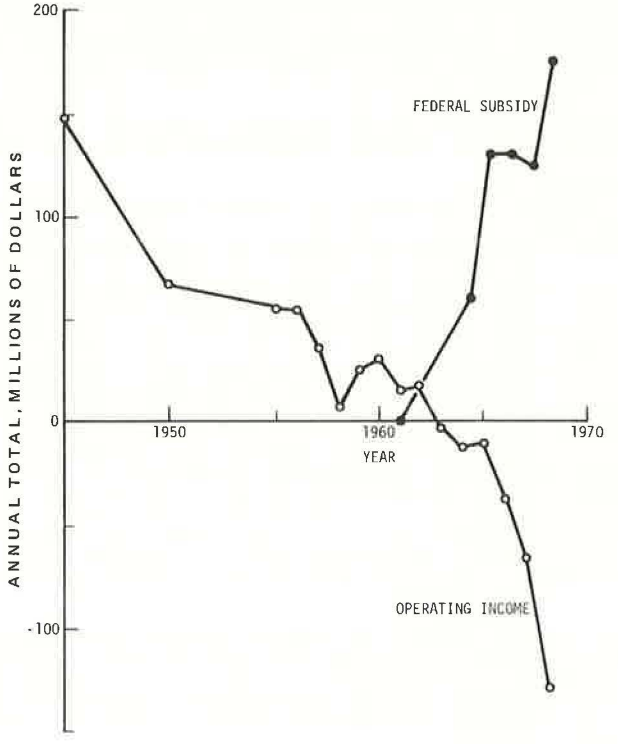

Figure 1. Trends of income and subsidy of transit in United States.

Of seven specific research and development (R&D) efforts enumerated by the President, five dealt exclusively with improvements in bus and rail systems. The plain implication, strengthened by subsequent congressional approval, was that more innovative "new systems" are less urgently needed. Over the years, this has clearly been the federal position. Through fiscal year 1969, only 13 percent of total R&D expenditures had been allocated to new systems (5). Even so, subsequent congressional criticism of R&D focused on "rather exotic ideas... too far out to merit expenditure of money at this time" (6). In fiscal 1970, R&D allocations to new systems dropped to a low 6.8 percent of the total.

Given this background, changes planned for fiscal 1971 are truly dramatic; the new systems allocation is to increase to 39 percent of total R&D support (5). If the past is any indication, enthusiasm for this sort of change may be spotty in both government and industry. Yet detailed analyses show that it is not only desirable but also essential if the stated goals of the new federal transit program are ever to be fulfilled.

ANALYSIS OF NEW SYSTEMS

To date, federal transit R&D has concentrated on improving conventional bus and rail systems. In conventional rapid transit, many people are hauled simultaneously in a single conveyance along a single route. All passengers in the vehicle must stop for all pickups and discharges. Consequently, high average speeds are impossible unless stations are very widely spaced; but if stations are widely spaced, then most passengers must resort to inferior secondary transportation modes for access, which often consume more time than is saved aboard the primary system.

New systems, generally speaking, offer relief from the basic limitations of conventional systems. The principal conceptual opportunity is "personal transit," in which individual vehicles are provided for individual travelers. In personal transit, small vehicles rather than large ones would move automatically on electrified, grade-separated guideways. All stations would be placed on sidetracks so that only those vehicles bound for a particular station would stop at it. Accordingly, personal transit would provide nonstop service without waits or transfers between any pair of stations, at double or triple the overall speed of conventional rapid transit.

In addition, personal transit opens a major avenue for future development. With proper design foresight and the addition of suitable on- and off-ramps, a personal transit system could readily accommodate dual-mode automobiles as well as transit cars. These automobiles would be manually operated when on city streets and could be privately owned. Thus personal transit might smoothly evolve into a complete dual-mode transportation system. In addition to a breakthrough in transit performance, it would provide the equivalent of freeway automation and electrification, with attendant major benefits for private motorists in particular and the urban environment in general.

Such potential for important new functions does not exist in conventional transit. New technology is applicable, of course, but its effect will be very much limited by the basic conventional concepts. Thus redesign and automation of transit trains, for example, will eliminate none of the intermediate stops and transfers now necessary and consequently will at best provide modest changes in system performance.

To a large extent, the proper allocation of R&D between conventional systems and new systems depends on their prospective performance, impact, and technical feasibility. Considerable light is shed in this area by the series of new systems studies completed by the U. S. Department of Housing and Urban Development for Congress in 1968 (7). Among these new systems studies, the analysis performed by General Research Corporation (GRC) is especially topical because its results happen to be stated precisely in terms of the beneficial impacts cited by President Nixon in advocating balanced transportation to Congress (8).

The objective of the GRC analysis was to determine the relative merits of conventional, improved, and innovative urban transportation systems in the years to come. It was based on a series of quantitative case studies in which promising alternative transportation systems were matched with urban environments representative of the nation's larger cities, present and future. A computerized network flow model and cost-benefit assessment were employed to make a detailed evaluation of each case under study on a uniform and comparable basis.

Two large cities were selected by GRC for detailed case studies after a statistical survey of large cities revealed that results for them could be generally applied. Boston was chosen to represent transit-oriented cities, which are generally old, dense, and centrally focused. Houston was chosen to represent automobile-oriented cities, which are comparatively new, dispersed, and unfocused. Together, these two cities reasonably represent the range of possibilities of cities with total populations of more than a million—with the solitary exception of New York, which is unique by virtue of its absolute size, overall and central densities, and historic dependence on a very extensive system of rail rapid transit.

Quantitative descriptions and projections of land-use and travel demand were taken from existing transportation studies in Boston and Houston. Freeway systems in each of the cities, existing and planned, served in every case as background and context for design and evaluation of alternative transit systems. In Boston, where rail rapid transit had long been in operation, plans for extensive modernization and expansion had already been developed; these were taken as a basis for expanded systems of conventional facilities. In Houston, where such plans were not available, alternative transit networks were developed directly from analysis of land use, desire lines, and potential flows on a transit spiderweb network. Guideway route networks were developed similarly for personal and dual-mode service in both cities. In every case, conventional rapid transit was augmented with a comprehensive set of express bus feeders, while local circulation in denser areas was supplemented with a network of local bus service based on existing patterns of operation.

Guideway speed and capacity specifications of 60 mph and 6,000 cars (and passengers) per hour were selected to be reasonably conservative, yet with no undue sacrifice of performance advantages. Considerably higher performance might actually be obtained; even with considerably lower performance, guideways would be desirable and useful (9).

Prospective performance of alternative transportation systems was evaluated by means of a network flow simulation. The transportation network included all segments of door-to-door trips—walking, waiting, riding, transferring, and parking. Traveler choices among alternative modes in the network were chosen in accord with a modal-split formula that has been tested and validated for several major cities (10). In general, this modal split should be most reliable for conventional bus and rail transit because it was derived from empirical patronage studies for these kinds of transportation. For personal and dual-mode transit, its use should considerably underestimate transit patronage because it does not reflect the superior amenities of these modes relative to conventional transit. Transit fares were set for all systems at 60 percent of automobile costs.

Because congestion is potentially so important a deterrent to automobile usage and because its reduction is so important an objective of transit subsidization, the network flow simulation was arranged to deal explicitly with congestion. Separate matrices were developed to describe typical peak and off-peak (midday) travel demand, and each transportation system was tested separately for its ability to serve these very different conditions.

The network flow simulation was validated by application to surveyed conditions in Boston and Houston. In both cases, the simulation runs regenerated modal splits, artery volumes, street and freeway speeds, and other measures that were in excellent accord with actual observations at the time of the origin-destination survey and facility inventory.

About 40 alternative systems were analyzed for Boston and about 30 for Houston. For consideration here, a very limited set of 10 examples (five for each city) suffices to show comparative advantages of conventional and new transit systems. The first two examples are presented for reference as performance benchmarks; they are simply the previously noted validation runs that describe surveyed conditions for Boston (in 1963) and Houston (in 1960). The second two examples are conventional systems for the future (1975 and 1980 respectively) that have been balanced by substantial investment in new transit. In the third pair of examples, the balanced systems are improved by a 50 percent speedup of rapid transit, which is representative of a major improvement that might possibly be achieved through conventional systems R&D. The fourth and fifth pairs of examples are personal transit and dual-mode systems, which represent new systems R&D might make possible.

The basic route mileages of the examples considered here are given in Table 1. The future transit mileages shown were generally selected to give comparable dollar costs per delivered passenger-mile—about 6 cents in 1965 dollars, including all depreciation and amortization as well as direct costs of operation. In Houston, however, only the new systems could operate at this figure; rail transit costs for the systems shown were nearly twice as high and were not substantially reduced by elimination of system mileage.

COMPARATIVE EVALUATION OF SYSTEM PERFORMANCE

The proper allocation of R&D between new and conventional transit systems depends in part on the levels of costs and benefits that might be obtained through ultimate system use. Selected cost-benefit forecasts, developed as described in the previous section, are shown in Figures 2 and 3.

The proper allocation of R&D also depends on the particular goals and objectives of the new federal program for balanced transportation. These objectives were concisely

TABLE 1

MILEAGES OF GRADE-SEPARATED RIGHT-OF-WAY FOR ALTERNATIVE SYSTEM EXAMPLES

System	Boston (miles)		Houston (miles)	
	Freeway	Transit	Freeway	Transit
Reference	237	41	37	0
Balanced-conventional	375	62	261	64
Improved-balanced	375	62	261	64
Personal-transit	375	200	261	109
Dual-mode	375	600	261	193

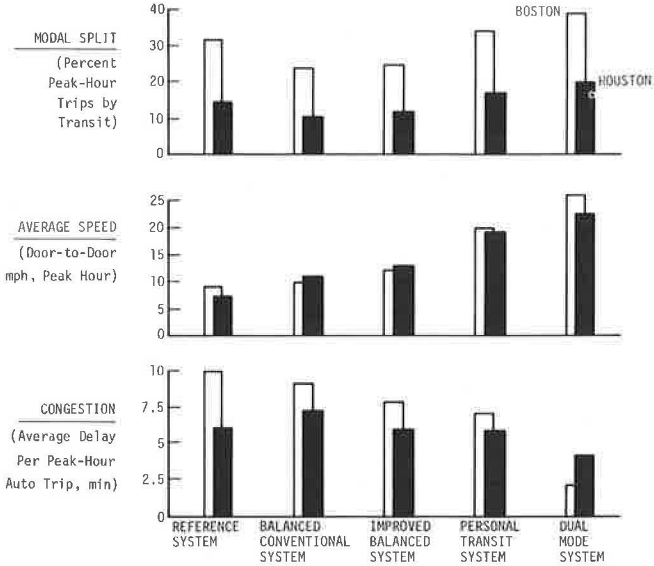

Figure 2. Transit attractiveness, service, and impact on congestion.

summarized by President Nixon in proposing the new program to Congress. The measures shown in Figures 2 and 3 were selected in accord with these objectives from the much wider range of measures originally calculated.

In this section, the President's objectives are repeated verbatim, one by one, and compared with the appropriate forecasts shown in Figures 2 and 3.

"The way to break that cycle [of declining transit patronage and impact] is to make public transportation truly attractive. . . ." The first forecasts shown in Figure 2 are

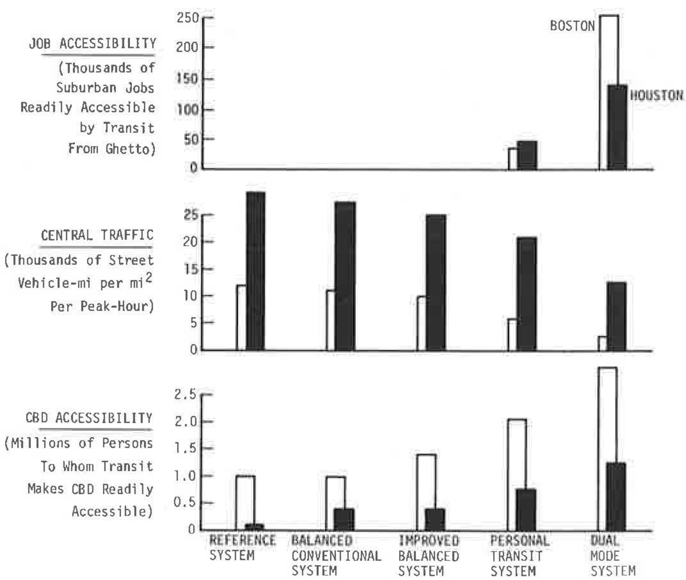

Figure 3. Transit impact on job accessibility, central traffic, and accessibility of the central business district.

modal splits, which quantify prospective patronage to be attracted by alternative transit systems in typical large cities. They indicate that increased investment in conventional transit is not likely to arrest the persistent patronage decline that plagues public transit; that R&D enabling a substantial improvement in conventional performance would not very much improve matters; and that real hope for maintaining and improving transit attractiveness rests with new systems of personal and dual-mode transit.

"The bus rider, train commuter, and subway user would have better service." The second forecasts shown in Figure 2 are door-to-door average speeds for transit travelers; because such averages reflect walking, waiting, and transferring as well as riding, they cover one dimension of overall service. The other dimension, area served by transit, has already been indicated in the system mileages given in Table 1. The figures show that balanced and improved conventional systems will indeed improve speed and coverage. Much larger increases, however, would be provided by the new systems, and without these large increases transit will continue to offer service that is a poor second to that provided by the automobile.

"The car driver would travel on less congested roads." The third forecasts shown in Figure 2 measure congestion directly. They make plain that, while conventional systems should produce worthwhile reductions in congestion, only the development of new systems promises major reductions in time losses due to traffic congestion.

"The poor would be better able to get to work, to reach new job opportunities and to use training and rehabilitation centers." The first forecasts shown in Figure 3 are the number of suburban jobs readily accessible by transit from ghetto areas, the heart of urban poverty. Total travel times of 30 min for Boston and 20 min for Houston were used as measures of "readily accessible"; these were approximately the average transit trip times for the reference systems in the two cities. The importance of suburban job opportunities is very great. In Boston, for example, all the growth in total employment projected for the period 1963 to 1990 appeared in the suburban areas. The forecasts shown in Figure 3 indicate that only the new systems will make the new jobs of the suburbs accessible to those most needy. This is partly because the new systems can economically offer much wider geographic coverage and partly because they offer the high speeds that make longer trips practical for daily commuting.

"The centers of big cities would avoid strangulation. . . ." The second forecasts shown in Figure 3 indicate the extent to which central streets are choked with vehicular traffic. They indicate that, although conventional systems offer modest reductions in traffic, personal transit promises improvements several times as great, and only the dual-mode system promises major removal of vehicles from the streets.

". . . and the suburbs would have better access to urban jobs and shops." The last forecasts shown in Figure 3 are the number of people for whom transit might make the central business district readily accessible, using the 30- and 20-min criteria of accessibility already described. They show that the total number could be substantially increased by balancing and improving conventional systems. They also show that increases three to five times greater could be obtained through new systems.

THE NEED FOR INNOVATION

Analysis of alternative systems of public transportation indicates that, in general, balancing conventional transit will produce worthwhile results and that R&D in conventional systems might produce worthwhile additional improvement. Analysis also indicates, however, that far more would be gained through the development and application of new systems.

If balanced conventional systems promised adequate beneficial impact, then new systems would be unnecessary, despite their superior potential; however, this is not the case. In terms of the express goals of the new program for balanced transportation, quantitative analysis shows that conventional systems are not enough. Only new systems of personal and dual-mode transit promise to offer service that will be generally attractive. Without attracting increasing proportions of travelers, no transit system can hope to produce the beneficial impacts that motivate the new federal program.

Past allocations of federal R&D effort overwhelmingly favored conventional systems. A change in direction is emerging, however; if encouraged and expanded, it could enable the new federal program to achieve its basic objectives.

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