TRANSPORTATION FOR A NEW TOWN

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Columbia, Maryland, is a new town currently under construction in the Baltimore-Washington corridor. The transportation system for this town includes a street network, a pathway network, and a proposed innovative transit system. The transit system design evolved from a systematic study of Columbia's needs versus available technology. Transit ridership was forecast for several alternate transit configurations involving various sizes of buses and various new types of transit systems. Scheduled and demand-actuated methods of operating were examined. The alternate transit configurations were evaluated from a number of standpoints including service provided, riders attracted, capital costs, operating costs, and financial feasibility. The recommended transit system would consist of 300 six-passenger vehicles operating automatically on 17 miles of two-way exclusive right-of-way and ten 25-passenger buses operating as a feeder service to the automatic system. A majority of the trip origins and destinations in Columbia would be within a 3-min walk of one of the 46 stations on the exclusive right-of-way. The system would attract around 17 percent of the trips and is financially feasible.

•NEW TOWNS, when properly planned, can offer an attractive alternative to the all too common metropolitan blights of urban sprawl, minority ghettos, and unimaginative "bedroom" suburbs. The new-town concept differs from the conventional suburban subdivision in that it contains all the ingredients for a full life (homes, jobs, stores, schools, churches, recreation, and other institutional facilities) in a convenient and rational relationship. One of the most powerful tools that the urban planner can use to achieve these new-town objectives is a well-planned, integrated transportation system around which the land-use plan is developed in a logical manner.

One example of such a new town is Columbia, Maryland, now under construction in the Baltimore-Washington corridor. By 1980, this new town will have a population of more than 100,000 and will occupy more than 25 sq miles, an area slightly larger than that of Manhattan.

Every effort has been made to ensure that the various attributes that many communities lack will be provided in Columbia. Columbia is being built according to a downtown-village-neighborhood hierarchical plan. Downtown will be surrounded by villages of 10,000 to 15,000 persons and various employment centers. Each village in turn will be made up of neighborhoods housing 1,500 to 2,000 people. Approximately 20 percent of the land will remain open land as pathways, parks, woods, common areas, and bodies of water.

Integrated into the land-use plan is a transportation system that includes three parts: (a) street network, (b) pathway network, and (c) transit network. The street network consists of freeways, parkways, village roads, neighborhood roads, and local cul-de-sac streets. The pathway network is designed to separate pedestrians from vehicular traffic. Each neighborhood will have a pathway system that connects it to the village center and in turn to downtown. The transit right-of-way is integrated into the land-use plan such that 40 percent of the ultimate population will be within a 3-min walk of the right-of-way.

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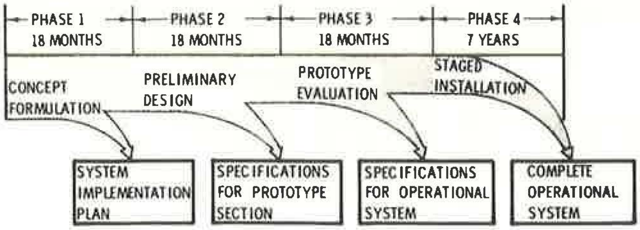

Figure 1. Columbia Transit Program.

This paper describes the approach and the results of a study to plan a transit system for Columbia. The study was conducted for Columbia under a U. S. Department of Transportation funded technical grant and was designated the Columbia Transit Program.

The Columbia Transit Program is divided into four phases as shown in Figure 1. Phase one, the concept formulation phase, used the systems approach that included the six tasks shown in Figure 2. The sections that follow describe each step of the process and the results.

PROBLEM DEFINITION

Problem definition included the following activities: (a) documentation of the broad urban objectives of the developer, (b) identification of the transportation implications of these objectives in terms of system development goals, (c) establishment of the constraints within which the transit system must be developed, and (d) development of the evaluation criteria for each system development goal.

The broad urban objectives for Columbia were sorted into transportation and non-transportation related areas. The transportation goals then led to the following two basic mobility goals: (a) provide mobility for those who are substantially dependent on public transportation and (b) provide a choice of travel mode for those in a position to choose between public and private transportation. The latter goal led to 11 detailed mobility goals. The mobility goals then led to the system goals, which were grouped in four areas: (a) technological, (b) aesthetic, (c) environmental, and (d) economics.

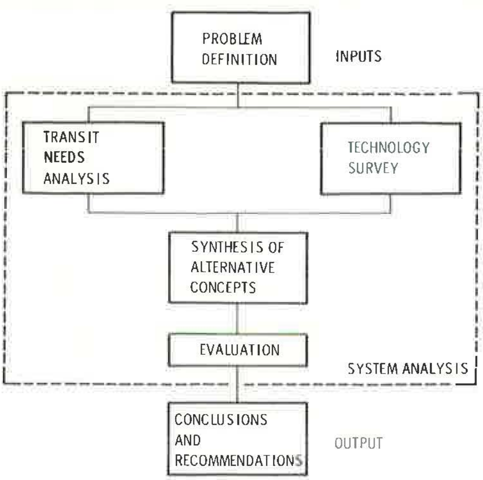

Figure 2. Systems-oriented approach to concept formulation.

The technological goals for the system, for example, included the following:

1. Eliminate or minimize potential interference among classes of movement, i. e., provide a separate transit right-of-way with grade separations at intersections with major roads;

2. Have a potential for growth, i. e., do not allow incremental or major extensions to the system either to give rise to disproportionate cost increases or to disrupt the operation of existing parts of the system;

3. Have a high level of safety and security where safety refers to the avoidance of collision or other events resulting in accidental damage to people or property and security refers to measures to avoid vandalism or malicious damage to people or property;

4. Provide a high level of service with respect to items such as routes, frequency of service, hours during which service is provided, and interfaces with external systems

at a modest user-perceived cost and at a reasonable capital cost; and

5. Be conveniently accessible to the population.

Problem definition also resulted in a statement of constraints or limits within which the Columbia transit system must be designed and operated. These are boundary conditions that cannot easily be relaxed or altered. The classification highlighted the cognizant agency for each constraint and the probable nature of the interaction. The constraints were identified in four categories: (a) legal, (b) economic, (c) right-of-way and land use, and (d) other. The "other" category included constraints such as a system implementation schedule that is consistent with Columbia's development plan and one that is of the right scale for Columbia.

Evaluation criteria were developed for each of the expanded objectives. Where feasible, these criteria were defined to permit quantitative evaluation using analytical techniques. For those criteria that did not lend themselves to analytical evaluation, arbitrary, but semiquantitative, evaluation techniques were developed. The latter included checklists and rankings on arbitrary numerical scales by a review board.

TRANSIT NEEDS ANALYSIS

The basic output of the transit needs analysis was a demand model. Because Columbia is a new town, it was not possible to follow the usual transportation planning approach of calibrating travel forecasting models based on existing travel patterns. For Columbia, travel demand had to be forecast for activities and people that did not exist.

Figure 3 shows the steps used to project passenger demand for Columbia. A classification rate analysis was used to estimate trip generation. Trip distribution was based on a gravity model, and K-factors were introduced to take into account an anticipated tendency of Columbia's residents to interact more frequently within Columbia than would normally be predicted by the gravity model. Because the pathway network would provide for walking in Columbia, walk trips were included in trip generation and trip distribution. The initial modal-preference model separated walk trips from vehicle trips. The person-vehicle trips were then factored to obtain peak-hour person-vehicle trips.

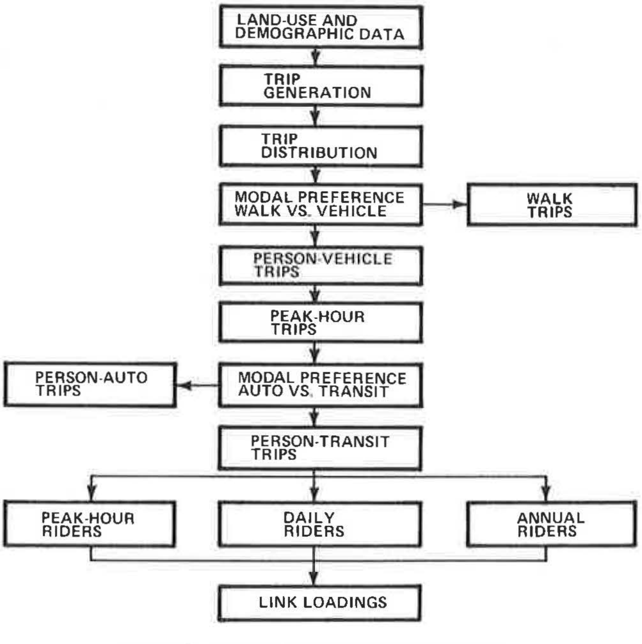

Figure 3. Projection of passenger demand.

The second modal-preference model was for automobile versus transit trips in the peak hour. This model took the form of diversion curves based on door-to-door travel-time ratios, cost ratios, and service or excess travel-time ratios for transit as compared to automobile. Person-transit trips could then be determined for the selected transit system configurations as a function of their characteristics. The number of peak-hour riders was converted to the number of daily and annual riders by applying appropriate factors. The daily factor was 90 percent of the peak-hour percentage, and the annual factor was based on Saturday and Sunday obtaining 50 and 25 percent respectively of the weekday riders.

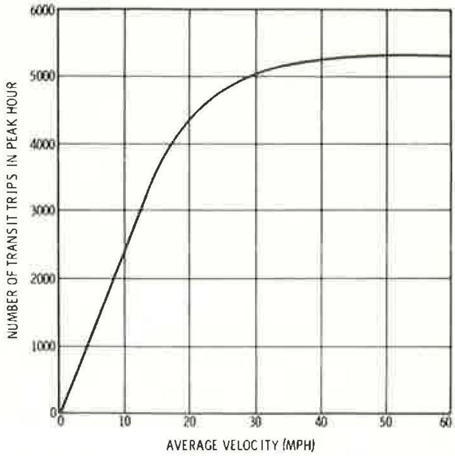

Figure 4. Primary system demand variation with velocity.

Generally the demand forecasts were obtained in parametric form for a range of system physical and operating characteristics. Sensitivity analyses were made for a range of fares, headways, and speeds. A typical demand curve for a personal, demand-responsive, automatic transit system on an exclusive right-of-way is shown in Figure 4. This curve is based on selected fare and headway levels and was used to assist in making a trade-off on vehicle speed versus number of vehicles.

TECHNOLOGY SURVEY

A survey was made to identify a complete spectrum of transportation systems. The resulting tabulations of physical characteristics, performance, availability, and cost were used in the synthesis task.

CONCEPTS SYNTHESIS

The concepts synthesis task identified two concepts and six systems. The two concepts were concept guideway and concept roadway. Concept guideway would provide completely automatic, nonstop, station-of-origin to station-of-destination service via six-passenger vehicles operating on a guideway built on 17 miles of exclusive right-of-way shown in Figure 5. All portions of the guideway are for two-way service. Forty-six stations are provided. Figure 6 shows a possible vehicle and guideway integrated into Columbia. The vehicle would offer privacy and comfort at least equivalent to that of an automobile. Concept roadway would provide transit service via buses on a paved, exclusive right-of-way shown in Figure 5.

Six transit-related systems were identified in concepts synthesis. These included the primary, feeder, operations and maintenance central facility, downtown distribution, transportation center, and regional bus systems.

Within the two concepts, eight alternate configurations were developed. The eight configurations were derived by combining the six systems previously listed in various combinations with various levels of service. The resulting eight configurations included three under concept guideway and five under concept roadway. Table 1 gives the systems included in each configuration, and Table 2 gives the service factors for the

TABLE 1

ALTERNATE CONFIGURATIONS

System	Guideway			Roadway				
	I	II	III	I	II	III	IV	V
Primary	X	X	X	X	X	X	X	X
Feeder	X		X	X		X	X	X
Operation and maintenance central facility	X	X	X	X	X	X	X	X
Downtown distribution	X	X		X	X	X		
Transportation center	X	X		X	X	X		
Regional bus	X	X		X	X	X		

Figure 5. Location of transit right-of-way and stations.

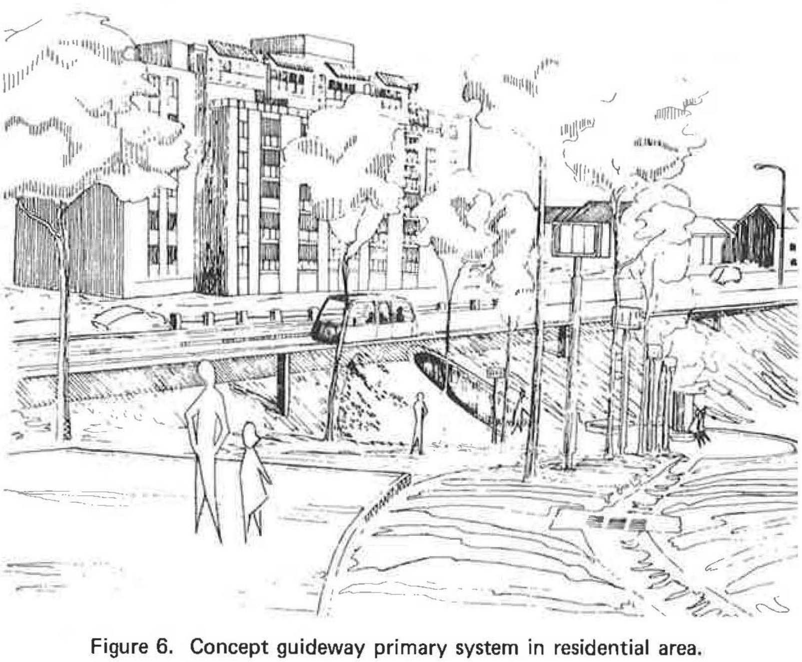

Figure 6. Concept guideway primary system in residential area.

TABLE 2
SUMMARY OF SYSTEM PARAMETERS

Configuration	System	Density of Area Served	Days per Week	Service (hr/day)	Peak-Hour Headway (min)	Average Vehicle Speed (mph)	Number of Vehicles	Vehicle Capacity (seated passengers)	1985 Riders per Day
Guideway I	Primary	High	7	24	2	35	470	6	40,370
	Comp. feeder	Low	7	18	18	15	21	15	11,220
	Total	All Columbia					491		40,370
Guideway II	Primary	High	7	24	2	35	310	6	29,150
Guideway III	Primary	High	7	24	2	35	320	6	30,100
	Nominal feeder	Low	6	12	90	15	10	25	950
	Total	All Columbia					330		30,100
Roadway I	Primary	High	7	24	9	15	19	50	17,870[a]
	Comp. feeder	Low	7	18	18	15	45	15	9,580[a]
	Total	All Columbia					64		27,450
Roadway II	Primary	High	7	24	9	15	19	50	17,870
Roadway III	Demand bus	All Columbia	7	22	10	15	78	15	30,170
Roadway IV	Primary	High	7	24	9	15	19	50	18,620
	Nominal feeder	Low	6	12	90	15	10	25	750
	Total	All Columbia					29		18,620
Roadway V	Nominal single	All Columbia	6	12	90	15	17	25/50	1,360

[a]This is the only case where riders on primary and feeder systems are additive.

primary and feeder systems of each configuration and also gives other system parameters including operational, equipment, and ridership characteristics.

EVALUATION

The objectives of the evaluation task were to rank the eight system configurations and to apply a financial filter to eliminate any configurations whose cost exceeded available resources. The ranking was accomplished by assessing each configuration in terms of each of the evaluation criteria developed in the problem definition task. By a process of weighted averages, ratings for each individual criterion were combined to establish a single overall figure of merit for each configuration.

To accomplish this assessment, it was necessary to describe each configuration in at least generic terms. To do this, various types of hardware were examined. By using the automatic system as an example, the proprietary candidates identified in the technology survey task were evaluated, and the number of candidates was reduced to 15. Each of these 15 surviving candidate systems would meet the established system requirements, although modifications would be required in some cases.

After defining the generic hardware, it was possible to perform a financial analysis for each configuration. Capital, operating, and maintenance costs were estimated for each configuration, and a 20-year financial analysis was made. Some results of the financial analysis are given in Table 3.

The financial analysis indicated that concept guideway has higher capital costs than concept roadway. It also has positive net cash flow versus negative net cash flow for concept roadway. Guideway, with its more extensive capital requirements primarily for automation, results in a system that requires a minimum number of operating personnel. Roadway, on the other hand, with its manually operated vehicles, has less capital investment but more operating personnel requirements. All three guideway configurations yield net cash flows for debt service. The roadway configurations do not. The most financially attractive guideway configuration is Guideway III. Guideway III, under conventional financing assumptions, requires support of 69 percent of the total capital and land costs and is estimated to cost $34.5 million.

As a result of applying the financial filter and completing the evaluation of the economic objectives, five configurations were eliminated as exceeding probable available

TABLE 3

SUMMARY OF FINANCIAL ANALYSIS

Configuration	Cost			Annual Revenue and Cost at Full Development		Capital Support Required, Including Land (percent)	Total Support Required During Development Period		Peak Cumulative Capital and Operating Cash Required	
	Capital	Land	Total	Revenue	Operation and Maintenance Costs		Operating	Capital	Year	Amount
Guideway I	36,827.6	4,295.0	41,122.6	2,542.0	2,439.3	88	5,742.4	41,832.0	1983	42,180.6
Guideway II	33,893.0	4,295.0	38,188.0	1,916.4	1,360.0	78	667.0	30,541.4	1979	32,947.8
Guideway III	30,221.0	4,295.0	34,516.0	1,476.7	622.1	69	33.8	23,993.9	1977	26,446.6
Roadway I	12,416.2	4,295.0	16,711.2	1,887.0	3,663.9	74	23,352.3	35,768.5	1985	35,768.5
Roadway II	9,852.7	4,295.0	14,147.7	1,397.7	1,708.9	70	6,852.1	16,704.8	1985	16,704.8
Roadway III	13,667.3	4,295.0	17,962.3	2,022.7	6,464.2	76	36,640.8	50,308.1	1985	50,308.1
Roadway IV	7,033.2	4,295.0	11,328.2	947.8	1,028.9	62	3,850.2	10,883.4	1985	10,863.4
Roadway V	2,228.6	–	2,228.6	66.2	244.4	100	2,183.4	4,414.0	1985	4,414.0

Note: Amounts are in thousands of 1970 dollars.

TABLE 4

SUMMARY OF ALTERNATE CONFIGURATIONS

Configuration	Vehicle Concept		Service Concept		Capital Cost (millions of dollars)	Capital Required (percent)	Net Revenue	Technical Risk	Ridership	
	Primary Right-of-Way	Low-Density Areas	Primary Right-of-Way	Low-Density Areas					Daily Trips	Relative (percent)
Guideway III	6-passenger automated	25-passenger bus	Nonstop, personal operation	90-min headway	34.5	53 to 69[a]	Sufficient to amortize 31 to 47 percent of capital cost	Significant	30,100	100
Roadway IV	50-passenger bus	25-passenger bus	90-min headway	90-min headway	11.3	62	Sustained annual deficit of $81,000	Minimal	18,620	62
Roadway V	50-passenger bus[b]	25-passenger bus	90-min headway	90-min headway	2.2	100	Sustained annual deficit of $178,200	Minimal	1,360	4.5

[a]Percentage of capital required depends on financing.
[b]Does not use right-of-way.

resources. The ranking of the remaining three configurations in order of goal satisfaction was Guideway III, Roadway IV, and Roadway V. Some of the characteristics of these three configurations are given in Table 4.

CONCLUSIONS

Of the three selected configurations, Guideway III is the top-rated candidate for further evaluation and consideration in the next phase of the program. Guideway III would be characterized by about 300 six-passenger vehicles operating automatically on demand on an exclusive right-of-way and ten 25-passenger buses operating as feeder service in the lower density areas. It would accommodate approximately 17 percent of the daily trips. Forty percent of the residential population, most of the retail, commercial, and institutional activities, and the entrances to the major industrial areas would be within a 3-min walk of the right-of-way.

Guideway III provides the highest level of service, attracts the highest number of riders, provides the only positive net cash flow, requires the lowest percentage of capital support, starts to pay for itself the earliest, requires the lowest operating support, and in general would provide a unique transit system for Columbia. However, Guideway III has the highest capital cost and the highest technical risk of the three selected configurations. It requires development of a relatively sophisticated control system. Additional development risks are involved because such an operational system has never been built.

By comparison, Roadway V provides the lowest level of service, attracts the lowest number of riders, operates at a deficit, and in general would provide a minimum level of service and a conventional type of transit system for Columbia. It is also the most economical roadway configuration and would offer low technical and development risk because of its conventional characteristics. Roadway V, however, does not satisfy the program goal of offering a realistic modal choice to noncaptive riders because of the low level of service provided. Therefore, it is not considered a viable alternative unless financing is unavailable for a more costly configuration.

Roadway IV, the next most economical roadway configuration, was selected as the preferred roadway configuration. Roadway IV would provide Columbia with a conventional bus transit system that satisfies the established program goals within the identified constraints. However, its merit rating as measured by the evaluation criteria established in problem definition was lower than that for Guideway III.

The concept formulation phase of the Columbia Transit Program demonstrated the technological and economic feasibility of providing public transportation in Columbia. Three configurations were identified, which, to varying degrees, meet the Columbia mobility objectives within a range of available resources. These three system configurations cover a spectrum of sophistication, service level, capital and operating costs, technical risk, and ridership.

The purpose of the next phase of the program is to investigate Guideway III in more detail including the preparation of preliminary engineering designs and precise cost estimates based on the engineering design. This information will permit a more informed decision to be made on which configuration should be taken into the acquisition phase.

REFERENCE

1. Columbia Transit Program Phase I. Bendix Corp., Ann Arbor, Mich., Pub. BSR 2814A, April 1970.