ONTARIO'S PROGRAM FOR INTERMEDIATE-CAPACITY TRANSIT

M. D. Harmelink, Ontario Ministry of Transportation and Communications

This paper describes the Ontario government's program for building and testing a demonstration transit system of intermediate capacity in Toronto. This demonstration system is considered a forerunner and test-bed for revenue systems, which, it is anticipated, will be built in major Ontario cities in the next decade. The scope of the revenue systems is also described as are the government's plans to develop an industrial capability in Canada for developing improved transit systems.

•IN November 1972, Ontario Premier William G. Davis announced a new urban transportation policy for Ontario (1). The policy, which is intended to shift emphasis from urban expressways to a variety of transportation facilities, will be implemented through a 6-point program administered by the Ministry of Transportation and Communications. The program includes

1. Subsidies of 75 percent for the purchase by municipalities of buses, streetcars, trolley buses, and related facilities;
2. Development, at provincial expense, of a prototype and operating demonstration of a new form of intermediate-capacity transit system together with a subsidy program of 75 percent to assist municipalities in applying the system to meet their needs (in Ontario, the highest priority candidates for such systems were identified as Toronto, Ottawa, and Hamilton);
3. Subsidies of 75 percent for studies and programs to alter demand for transportation at peak times such as the encouragement of staggered or flexible working hours to spread peak loads in major cities;
4. Subsidies of 50 percent to urban areas for upgrading and expanding computer-controlled traffic systems;
5. Subsidies of 75 percent for the continuation and expansion of transportation studies in cooperation with municipalities to maximize the use of existing roadways through the study of means such as 1-way streets and delivery and parking policies; and
6. Intensification of provincial efforts and resources to coordinate transportation planning among the municipalities in Ontario.

These new steps are in addition to the following previously introduced programs that will be continued:

1. Development, in partnership with municipal authorities, of new transit systems and upgraded existing ones;
2. Provision of aid to municipal transit systems in the form of deficit subsidies (50 percent of the deficits incurred up to a maximum amount limited by a formula); and
3. Financing of demonstration projects in the public transit field (e.g., demand-responsive buses and worker buses).

This brief description sets the framework of the province's urban transportation program. The rest of this paper deals with one of these program elements: the intermediate-capacity transit program.

BACKGROUND TO EVALUATION STUDY

The activity leading to the intermediate-capacity transit system program announced late in 1973 began in 1970 when the Ontario Ministry of Transportation and Communica-

tions convened a Transportation Technology Task Force with representatives from the provincial and federal governments, municipal planning boards, the Toronto Transit Commission, and private industry. The task force reviewed the status of development of new transit system concepts and technology. On the basis of extensive discussions, literature reviews, commissioned technical studies (including an inventory of more than 200 systems), and visits of inspection to a number of system developers in North America and Europe, the task force identified intermediate-capacity transit as a primary urban transportation need. Such systems could be used as a secondary or feeder system supplementing subways in large urban areas or as the primary system in cities of intermediate size. The capacity range to which these systems are most applicable was identified as approximately 6,000 to 20,000 passengers per hour per direction—the range in which low-capacity buses are inadequate, particularly on shared rights-of-way, and high-capacity subways are not usually economically feasible. The partial penetration of the new intermediate systems into traditional bus and subway capacity ranges was also considered a real and attractive possibility.

The Ministry of Transportation and Communications subsidizes transportation planning, construction, and operation in Ontario municipalities for both road and transit facilities and also acts in a technical advisory capacity to them. The ministry, therefore, has a strong interest in assessing the applicability and status of new transit systems across a broad spectrum of applications, including capacity, type of service, and urban environment. Following the activity of the Transportation Technology Task Force was the announcement by Premier Davis in October 1971 of a study for the evaluation and selection of intermediate-capacity transit modes for use in Toronto and other Ontario municipalities. The selected system would be tested at a demonstration track to be built in Toronto and thereafter installed in Ontario municipalities.

OBJECTIVES OF EVALUATION AND SELECTION STUDY

The objectives of the evaluation and selection study were as follows:

1. To evaluate intermediate-capacity transit systems relative to conventional transit systems across a broad range of capacity and network requirements (the optimum ranges of application of the feasible systems were expected to emerge from the study, permitting the best matching of systems to requirements in Ontario municipalities);
2. To evaluate in terms of engineering design and hard costs the most promising systems for application to a specific site in Toronto; and
3. To select one system for testing and demonstration on a track to be constructed at the selected Toronto site.

OBJECTIVES OF THE TRANSIT DEMONSTRATION SYSTEM

Since one objective of the evaluation study was the selection of one system for demonstration, it is appropriate to address the question, Why a demonstration system at all? When this question is asked, the usual related question is, Why not let the systems developers proceed until they have demonstrated a feasible, reliable system?

One of the strongest reasons for proceeding along the selected path was that of time. Left to themselves, various systems developers might eventually develop a system that would appear to match a "customer's" needs with greater or lesser degrees of success. However, left to themselves, or with the usual limited government funding distributed among them, the process of developing and proving the systems might also take many years. If the advanced systems do exhibit all, or even some, of the claimed advantages over conventional systems, the ministry considered that they should therefore be implemented soon rather than late to start reaping the benefits from their introduction. Furthermore, by defining its requirements early, rather than letting development proceed to a final product, the ministry felt that the chances would be enhanced of having a system that met the defined needs, rather than vice versa. Finally, a demonstration system is a normal stage in the development progression: design to prototype to demonstration system to revenue system. It was felt that the demonstration system cost, although substantial, represented only a small percentage of the cost of the

ultimate revenue systems and was a worthwhile investment to ensure maximum benefits from the revenue systems.

The demonstration system is intended to test, insofar as possible, those features of the system related to typical transit characteristics and service. Demonstration system performance will be extrapolated to more extensive revenue applications in various Ontario municipalities. The objectives of the transit demonstration system are

1. To test technological feasibility (functional performance of the system and its various subsystems);
2. To test operational reliability in day-to-day service;
3. To test compatibility with climatic conditions in Ontario;
4. To provide real base data on costs (capital, operating, maintenance);
5. To test the passenger-carrying capability of the system;
6. To test the passenger-system interface and the passenger response to the system;
7. To test environmental impact (noise, visual intrusion); and
8. To provide a continuing test-bed for improvements in the system and subsystems.

SCOPE AND METHODOLOGY OF EVALUATION STUDY

Phase 1

On the basis of compiled information, 8 system developers were invited, in December 1971, to participate in the selection study. The developers were asked to provide detailed information on system and subsystem technology, performance, and capital and operating costs, as requested in a prospectus (2) accompanying the invitation to participate. General specifications only were given for parameters such as capacity, speed, safety, noise, ride comfort, and all-weather performance. The primary objective was to obtain information on the different systems to permit a comparative evaluation of them for a variety of applications. A developers conference was held in January 1972, and the developers were given 2 months to supply the information. The ministry felt that the developers should already have most of the requested information available, and, therefore, paid each developer only a nominal sum to cover costs of travel, reproduction, and mailing. The ministry team completed its evaluation and supporting analyses and the writing of more detailed specifications for phase 2 by August 1, 1972, as scheduled. The phase 1 evaluation resulted in the selection of 3 of the original 8 systems to proceed to phase 2. The 8 systems evaluated in phase 1 are given in Table 1.

Simultaneously with the evaluation, several other activities were initiated. The first was the selection and application for approval of the demonstration site. The second was the work on application studies: computer simulations applying the proposed systems to urban networks for real cities of varying size and tests of the sensitivity of cost and benefits to variations in parameters such as grid spacing (access time), head-

Table 1. Characteristics of systems evaluated in phase 1.

System	Design Concept	Automatic Command Control	Suspension	Propulsion
Alden StaRRcar (USA)	PRT	Yes	Rubber tires	Rotary ac motors, hydrostatic drive
Ford ACT	Line-haul or PRT	Yes	Rubber tires	Rotary dc motors
Transportation Technology, Inc. (USA)	PRT	Yes	Air cushion	Linear induction motors
Uniflo (USA)	PRT	Yes	Air cushion	Linear air turbine
Bertin Aerotrain (France)	Line-haul	Optional	Air cushion	Rotary or linear induction motors
Urba 30/100 (France)	Line-haul	Optional	Negative-pressure air cushion	Linear induction motors
Hawker-Siddeley Canada (Canada)	Line-haul with off-line stations	Optional	Rubber tires	Linear induction motors
Krauss-Maffei Transurban (Germany)	Line-haul or PRT	Yes	Electromagnetic	Linear induction motors

way, speed, and type of service. In addition, simulation studies of system performance and network dynamics were begun. These studies, and numerous discussions, seemed to indicate that feasible PRT systems were some years away for the following reasons:

1. Decision-makers would not likely approve, in the near future, areawide implementation of such a radical departure from conventional transit modes;
2. Feasible operation of PRT service appears to require extremely short headways, which, with the associated network dynamics, have not been demonstrated; and
3. The marginal benefits of PRT, compared with somewhat more widely spaced, frequent line-haul and express service, do not seem to justify the marginal costs (assumptions and claims made by PRT advocates in the past seem unduly optimistic).

The rationale was introduced into the phase 2 specifications (3) in these words:

> Preliminary assessments suggest that the first applications of advanced systems are likely to be of a "linear," line-haul nature. It is considered a good possibility, however, as transit systems and technology develop, that a transition to more extensive networks, smaller vehicles, shorter headways, and a more flexible and personal type of service will occur. It has been attempted in this specification for a demonstration system to keep a number of options open. The need for practical line capacities up to 20,000 passengers per hour per direction, with entrained vehicles, has been stressed, but at the same time intermediate size vehicles and short headways for single vehicle operation have been specified to permit, by testing, a start to be made on the transition to a more flexible and personal type of service.

Phase 2

The 3 system developers selected to proceed to phase 2 were Ford, Hawker-Siddeley, and Krauss-Maffei. The purpose of phase 2 was to generate a preliminary engineering design and a fixed-price bid on all elements of the demonstration system except the civil engineering (guideway and station structures) for which estimated costs are given. It was agreed that the prices established by a competitive tendering process with civil engineering contractors would be accepted at the time of implementation.

Partway through phase 2, the Ford Motor Company withdrew from the competition, having decided that to redesign its system to meet our specifications for speed and entraining capability was not in its corporate interest. The remaining 2 developers were each paid $50,000 to defray costs, and they submitted their technical design proposals and bids on February 1,1973, as scheduled. The technical evaluation process took 3 months, and during that time mutually acceptable contracts were negotiated with both submitters. The major evaluation criteria were as follows:

Item	Criteria
Company	Long-term contractual conditions (licensing, data rights, royalties, competitive bidding, Canadian content) Ability to deliver the system with the required performance on time and at contracted cost (project management capability, level of commitment, status of hardware development)
Cost	Itemized capital costs of demonstration system Itemized capital cost estimates of future application and revenue system
System	Technology assessment, by subsystem and total system, in terms of feasibility, quality of design, and integration of subsystems Flexibility of application, including type of application (capacity range, geometric criteria), type of operation (operating strategies, transitions in service level), and expandability (network expansion, higher speed potential, potential for goods movement)

Item	Criteria
System	Safety for users, nonusers, and maintenance and operating personnel Reliability, by subsystem and total system Environmental effects (aesthetics, pollution, noise and vibration, space consumption) User attributes (time and convenience factors, ride comfort)

The evaluation process resulted in the selection of Krauss-Maffei AG of Munich, West Germany, and a contract for the transit demonstration system was awarded May 1, 1973.

DESCRIPTION OF TRANSIT DEMONSTRATION SYSTEM

The site of the transit demonstration system (TDS) is located within the Canadian National Exhibition Park and adjacent to Ontario Place in Toronto (Fig. 1). The TDS will be built as a 1-way loop about 2.5 miles in length and have 4 off-line stations. Station 1 is at Princess' Gate, the main entrance to Exhibition Park; station 2 interfaces with the York Station of the provincially operated GO-Transit commuter rail line; station 3, at the Dufferin Gate, connects with a nearby parking lot; and station 4 serves the main entrance to Ontario Place. A maintenance building and storage track will also be connected to the guideway loop.

The guideway is almost entirely elevated. The alignment has been laid out to permit testing on short sections at speeds as high as 80 km/h on both straight and curved alignments. Fifteen vehicles (Fig. 2) will be acquired for testing. These will be capable of operating either singly or in trains of 2 or 3 vehicles. Characteristics and system specifications are given in Table 2. The total cost of the demonstration system is approximately $16 million.

IMPLEMENTATION OF DEMONSTRATION SYSTEM

The TDS program is now in phase 2, which consists of detailed design, construction, commissioning, and acceptance testing. The major planned events in phase 3 are as follows:

Event	Date
Developer receives system specifications	May 1, 1973
Start of commissioning	
1 to 2 vehicles	January 1, 1975
3 to 6 vehicles	January 20, 1975
7 to 15 vehicles	May 30, 1975
Completion of acceptance testing on 15-vehicle system	July 31, 1975
Turnover to ministry (contingent on completion of acceptance testing)	August 10, 1975

Phase 4, the proving test phase, is not covered by the current contract. However, the plan is that a successful phase 3 will lead to the following sequence in phase 4:

Event	Date
Proving test program 1 begins	August 10, 1975
Public passenger-carrying at Canadian National Exhibition	August 15 to September 5, 1975
Winter testing	December to April 1976
Proving test program 1 completed	September 15, 1976

Figure 1. Route of transit demonstration track in Exhibition Park, Toronto.

Figure 2. TU-02 Transurban prototype at Krauss-Maffei Plant, Munich, Germany.

Table 2. Characteristics of transit demonstration systems.

Item	Description or Specification
Vehicle capacity	
Nominal	12 seated, 8 standing
Crush	12 seated, 15 standing
Vehicle dimensions, m	
Length	6.5
Width	2.25
Height	2.8
Minimum turn radius, m	35
Suspension and guidance	Electromagnets on vehicle base attracted to armature rails on guideway; current in magnets regulated to maintain constant air gap; no secondary suspension
Switching	Magnetic switching on the vehicle; no moving parts on track; on-board mechanical switch arm deployed as safety backup
Propulsion	Linear induction motor controlled by inverter, fed from 600-volt dc power distribution system
Command and control	Full automation, with a hierarchical, relatively centralized control system; triple computer configuration used to ensure safety and improve reliability
Guideway	Reinforced concrete box beam 0.75 m wide, depth varying with span, spans up to about 30 m; mounted atop the beam is a "console" made up of magnet armature rails and linear motor reaction rail
Braking	Regenerative motor braking and emergency caliper brakes
Headway, sec	
At 48 km/h	10
At 72 km/h	15
At 48 km/h, for testing, without carrying public passengers	6
Operating speed, km/h	
Nominal	72
Maximum normal	81
Maximum acceleration-deceleration, g	
Vertical	0.10
Lateral	0.10
Longitudinal	0.15
Maximum jerk, g/sec	
Vertical	0.05
Lateral	0.08
Longitudinal	0.08
Noise	
Interior	PNC 60
Exterior	PNC 50 at 7.6 m
Supervisory schemes	Scheduled line-haul Scheduled line-haul mixed with express service On-demand service (PRT model)
Maximum grade, percent	6.5

Table 3. Revenue system costs.

City	Number of Routes	Double-Track Miles	Projected Cost (millions of dollars)	Projected Cost per Mile (millions of dollars)
Toronto	5	56	756	13
Ottawa	1	11	195	17
Hamilton	3	17	283	16

IMPLEMENTATION OF REVENUE SYSTEMS

The November 1972 transportation policy statement described a number of revenue routes for intermediate-capacity transit systems in Toronto, Ottawa, and Hamilton. Although specific routes were examined and described in each city, the intention was to indicate that such routes were feasible rather than to define unilaterally where such routes should go. In keeping with its past practice, the ministry intends to consult fully with each municipality to arrive at the best transportation solution in terms of modes, routes, and service.

Nevertheless, it is of interest to describe briefly intermediate-capacity transit networks postulated for each city and to indicate the scope of the government's intentions and commitment to better transportation for Ontario cities. These routes are given in Table 3. Costs per mile, which include some tunnel sections, are still quite favorable compared with current subway costs of $25 to $30 million per mile. The target date for implementation of the first lines was set as 1977; the majority of the lines are to be constructed within the next 10 years.

THE ONTARIO TRANSPORTATION DEVELOPMENT CORPORATION

The Ontario government has also taken steps to develop a Canadian industrial capability in advanced transportation systems. In June 1973, it set up the Ontario Transportation Development Corporation (OTDC), a Special Act Company, to hold and exercise the license rights acquired by the government from Krauss-Maffei during the contract negotiations. These rights and arrangements are

1. Exclusive license rights on all present and future technology, including all patents and industrial property associated with the Krauss-Maffei system, for any application in Canada (these license rights include a training and know-how transfer provision to ensure capability of application);
2. Nonexclusive license rights in Central and South America to ensure an export market for Canadian industry and a "most favored nation" provision for sales to the balance of the world, except the European Common Market (special provisions apply to the United States market where the OTDC receives a percentage of all royalty income from that market);
3. The right to sublicense companies in Canada for the manufacture and sale of complete transit systems, subsystems, and components;
4. A contractual commitment that prior to May 1, 1974, Krauss-Maffei will establish a Canadian controlled company in Canada to hold 1 such sublicense; and
5. A contractual commitment for the provision of future technological development by Krauss-Maffei.

The role of the OTDC will be

1. To coordinate and promote the development of advanced technology of all types relating to public transit and to integrate this development with the design and production of conventional transit facilities;
2. To fund research in transit innovations in intermediate-capacity systems and others; and
3. To market systems through the private sector in Ontario and in Canada.

The Canadian government and other provincial governments in Canada have been invited to participate in the transit and industrial program. Many detailed aspects of the program have yet to be worked out, but the estimated Canadian market for intermediate-capacity systems of $3 billion and the employment of approximately 15,000 workers for a 10-year construction period indicate that a cooperative arrangement among the governments of Canada and the private sector will lead to the best achievement of the defined goals.

REFERENCES

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