isting line-haul markets served by conventional mass transit (especially deficit ridden markets), its greatest threat is in capturing many new markets that otherwise would have gone to transit.

Not surprisingly, the possibility of missing out on these new markets and new jobs is causing transit unions considerable concern. But, aligned against the unions' interest in the new jobs is an impressive array of other factors, many of which are related to the need to reduce our dependency on the private automobile. Concern about air, noise, and visual pollution; energy use; congestion; and other unintentional social costs of automobile use have made it clear that public mass transportation must be expanded in a way that will attract private automobile users. Because paratransit is more flexible and offers a higher level of service, it has many inherent advantages over conventional mass transit for serving the automobile market.

At the same time that paratransit is being recognized as a possible alternative to the private automobile, the fiscal crises of many cities are causing general budgetary restraint and there is a growing understanding that UMTA capital and operating funds are also limited. The result of these fiscal constraints is that paratransit and conventional transit are competing not only for new jobs, but also for a limited and fixed amount of government subsidy.

A final factor favoring paratransit is the use of competitive brokerage to select new mass transportation services. By removing the institutional advantage existing transit would have for gaining new markets, competitive brokerage promises to reward the inherent advantages of paratransit, including its lower labor cost.

Against these factors is section 13c, which the transit unions are using both to block paratransit expansion and to gain control of any new jobs. While there is wide disagreement on the extent of the problem, section 13c clearly slows innovation.

But innovation will occur, and the unions have already shown, as in Cleveland, that they can be flexible enough to compete for many new markets. Flexible work rules should be a concession the unions continue to make to win new jobs. New job classifications should also be expected.

The central role of the MPO in promoting paratransit expansion makes it an ideal forum for resolving many of the debates about section 13c. In fact, many of the issues arising under section 13c are political in nature and belong more properly in the political forum provided by the MPO. It is, for example, a local political decision how to allocate UMTA money among different mass transportation services. It may also be advantageous to use the political forum to set wage rates for transportation services; a fixed budget ceiling should be the concern of all city managers. It is also a political decision to determine which transportation jobs are affected and how they are to be protected.

For these reasons, the MPO may have an increasing role in the section 13c process, from assisting management negotiate specific agreements to providing a specific account to pay claims. The MPO's political composition gives it needed authority and flexibility, as well as a concern for budgetary matters that is greater than many transit managers'.

The MPO is also in a good position to encourage trade-offs between new jobs and security for existing jobs. Agreements that are collateral to section 13c could also be used to advantage by the MPO. These agreements might set forth existing transportation conditions other than UMTA funds that can affect employees, facilitate reemployment of terminated employees, provide for the sharing of liability for claims, and keep accurate cost accounts of all claims.

In conclusion, even with the possible protection of section 13c, transit unions are being forced to be flexible to accommodate innovation and continue to expand. However, removing the application of section 13c to paratransit would accelerate this process without any serious harm to the unions.

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Requirements for Paratransit Vehicles

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The current state of the art of paratransit vehicles—the sizes and types used, the operating constraints, guidelines for size selection, a vehicle-tender selection process, current trends, and forecasts of the evolution of vehicle design over the next 10 years—is discussed. Action is suggested to reduce uncertainty over individual vehicle performance and improve utilization and design. Vans and integrally designed small

buses have proven more reliable than other types of vehicles; their use in Canada and the United States is discussed. The selection process described is used to analyze four theoretical vehicles being reviewed for procurement. The analysis shows that the most cost-effective vehicle could be a bus with the highest initial cost or a low-cost van.

A great variety of sizes and types of vehicles are currently being used in paratransit service. These include

1. Taxis and limousines (Checker Marathon and Aerobus models),
2. Vans (Fortivan, Transporter, and Maxivan),
3. Station wagons (usually for handicapped persons),
4. Modified recreation vehicles (General Motors small bus at airports and Winnebago),
5. Small buses on truck or recreation-vehicle chassis (Fleury, Flxette, Urban Transportation Development Corporation Club Car, Transcoach, Grumman, and Minibus),
6. Small school buses (Thomas, Bluebird, and Superior), and
7. Integral small-bus designs [Argosy, General Motors (series 30), Twin Coach TC-25, FMC Corporation, Rohr Flxible (series 30), and Mercedes-Benz 0309D].

The integrally designed vehicles (vans and some small buses) have been the most reliable from the point of view of the operator. Small buses created by designing a body shell and mounting it on a truck or recreation-vehicle chassis have more problems because the bodies are often too heavy for the available chassis, which results in premature brake and suspension failures and excessive maintenance costs. Many custom bus builders have gone out of business because of problems such as these.

In the United States, components for short drive trains, which are necessary for building a bus with a heavy-duty, low-profile chassis, are not readily available. To extend the life of the running gear, either a high-floor chassis must be used or the body mass must be lowered. FMC Corporation has achieved a low-profile bus through a special body design, and low-profile buses are being built in Europe (1).

Size requirements are usually based on either legal constraints (e.g., the case of taxis) or the maximum demand expected. In many cases, a larger vehicle than necessary is used by operators who are playing safe or do not want to purchase a new model for their vehicle fleet.

A general rule for selecting the sizes of buses for local collection-and-distribution service (the most common use) is given below (1 km = 0.6 mile).

Length of Vehicle Tour		
Time (min)	Distance (km)	Type and Size of Vehicle
15	<4.8	Taxi or 9- to 11-passenger van
20	<6.4	11- to 14-passenger van
30	<8	18- to 24-passenger bus
40	<16	24- to 35-passenger bus
60	<16	35- to 50-passenger bus

For communities of fewer than 50 000 persons, the following other factors should also be considered ($1\ km^2 = 0.39\ mile^2$).

Peak-Hour Demand (no. of passengers)	Vehicle Size (no. of passengers)
<100	6 to 11
100 to 200	11 to 15
200 to 500	22
>500	30

Peak-Hour Demand per Square Kilometer (no. of passengers)	Vehicle Size (no. of passengers)
<10	6 to 11
<20	15 to 22
>20	30

Experience with a variety of small vehicles in Canada and the United States has shown that, given the current state of the art, it is probably best to select one brand of vehicle and cope with its problems than to purchase a variety of problems. An excellent evaluation of current experience with a number of small vehicles is available from the state of Michigan (2). (The Canadian experience with small vehicles in paratransit service is almost identical to that in the United States. This paper, therefore, deals with the North American situation except where specifically noted.)

VEHICLE SELECTION PROCESS

Decisions to purchase certain types and makes of vehicles for paratransit applications are based on a variety of factors:

1. Personal preference of the operator,
2. Initial cost and resale value,
3. Availability of parts and service,
4. Ease of maintenance and operation,
5. Cost of maintenance,
6. Fuel consumption,
7. Durability (life),
8. Legislative constraints,
9. Special body or equipment options,
10. Reliability in service, and
11. Availability.

Personal Preference of the Operator

Personal preference factors are usually related to the degree of experience with a certain manufacturer or the public image of that type of vehicle. For example, the standard North American automobile is the dominant type of vehicle used as a taxi despite the fact that it is very poorly designed for the purpose. More expensive specialty vehicles such as those used in Europe and the U.S.-built Checker Cab are much better designed for taxi service but have a small share of the U.S. market (3).

It would be naive to believe that personal preferences do not enter into the selection of a vehicle when buying by public tender; both the preparation of specifications and the grouping of bid options can be used to favor a particular product.

Initial Cost and Resale Value

Decisions to purchase that are based solely on initial cost without consideration of durability and the cost of future maintenance are usually attributed to low-bid tendering by public operators. However, private operators may also be trapped into buying low-cost vehicles because of limited capital resources. Often the decision is based on price quotation only because there is a lack of in-service experience on which to base a choice among vehicles offered. Resale value is proportional to cost.

Availability of Parts and Service

This is a very important factor to both public and private operators. Most operators do not want to tie up capital funds in parts inventories and also prefer to deal with a limited number of suppliers. All operators want to deal

with the original supplier for warranty adjustments rather than with the individual component manufacturers. Operators with fewer than 20 vehicles in their fleet may want to be able to contract out their maintenance work to a local garage.

Ease of Maintenance and Operation

Many of the vehicles adapted for paratransit service are a mechanic's nightmare. In some, it is almost impossible to remove the engine or transmission as a unit because of conflicting body members. Changing a windshield-wiper assembly or other electrical component, for example, can be very time consuming. Most maintenance supervisors will resist buying such vehicles if they are consulted. Other operational considerations may include performance under extremely cold conditions or on steep grades. The ease of operation and maintenance may be partly related to the available power plant options.

Cost of Maintenance

This is a decision factor that at present is very subjective. It is known that, because of the state of the art, small buses are generally more expensive to maintain than large buses. Large, standard transit models have at least 30 years of development history. It is also obvious to anyone familiar with the automotive industry that new mechanical features, such as wheelchair lifts and ramps or kneeling buses, are likely to increase both operating costs and in-service failure rates.

What is not well-known are the differences among the various small vehicles with respect to in-service performances and maintenance costs. This results in considerable bias toward existing models.

Fuel Consumption

Fuel consumption considerations are becoming more important in an energy-conscious society. These considerations generally favor the use of diesel engines.

Durability (Life)

An assessment of durability must consider climatic conditions, terrain, and loading. A basic trade-off decision must be made when buying small vehicles for paratransit service between low-cost, short-lived vehicles and higher cost, more durable vehicles. If the minimum standards of comfort and safety can be met, it may be less costly to buy a low-initial-cost vehicle and write it off before it falls apart. Public operators tend to buy more durable vehicles because they have learned that they are often forced to keep their vehicles beyond a normal lifetime. Here again, as with maintenance costs, insufficient data are available for objective evaluation among models.

Legislative Constraints

At times, the operator does not have much choice because of constraints attached to government funding or because of very high safety or environmental standards. Examples of this are the government policy of buying locally made products and problems in meeting environmental standards with certain types of engines.

Special Body or Equipment Options

Certain models—e.g., low-profile buses and vehicles having good wheelchair lifts—may be selected because of their accessibility for handicapped persons.

Reliability

The reliability of a vehicle is measured negatively in terms of lost travel or length of time the vehicle is out of service because of a need for maintenance. This factor affects the number of spare vehicles that must be purchased.

Availability

The best designed vehicle is not an appropriate selection if it cannot be obtained (e.g., if the plant making it is on strike or cannot deliver by the due date).

APPLICATION OF SELECTION FACTORS (LIFE-CYCLE COSTING)

The use of the factors discussed above in the vehicle selection process can be illustrated as follows. From an offering of several small buses for a paratransit service, three models have been selected that meet the required delivery date, satisfy the funding regulations, and are generally acceptable in terms of durability, ease of operation, and availability of parts and service. The key considerations remaining are initial cost, reliability, cost of maintenance, and fuel consumption (4): Assume that the vehicles are operated 80 000 km/year (50 000 miles/year), fuel costs are $0.16/L ($0.60/U.S. gal) for gasoline and $0.13/L ($0.50/U.S. gal) for diesel, and there is a net average finance rate of 10 percent.

1. Vehicle A is a high-quality, integrally designed, diesel-powered bus with a 10-year lifetime. Its proven reliability indicates a need for 5 percent of the fleet as spare vehicles. Its average maintenance costs are $0.12/km ($0.20/mile). Fuel consumption is 6.4 km/L (15 miles/gal).
2. Vehicle B is a good-quality bus body attached to a truck chassis. It has a gasoline engine and a 5-year lifetime. Its record of reliability in other services indicates a need for 12 percent of the fleet as spares. Its maintenance costs are $0.20/km ($0.32/mile). Fuel consumption is high—2.1 km/L (5 miles/gal)—because of the mass of the vehicle.
3. Vehicle C is a low-cost, small school bus with a 4-year anticipated lifetime. It has a gasoline engine and a slightly better record of reliability than vehicle B, requiring 10 percent of the fleet as spares. Its maintenance costs are also lower—$0.17/km ($0.28/mile) and its fuel consumption is 3.2 km/L (7.5 miles/gal).
4. Vehicle D is a 14-passenger van with a 3-year anticipated lifetime. It has a gasoline engine with a reasonably good record of reliability for light automotive equipment. Because it has a relatively short maintenance cycle for brake and drive-component servicing, 10 percent of the fleet are needed for spares. Its maintenance cost is the same as that of vehicle A—$0.12/km ($0.20/mile)—and its fuel consumption is the same as that of vehicle C—3.2 km/L (7.5 miles/gal).

The cost analysis given in Table 1 shows that vehicles A and D are the lowest cost options. In spite of its high initial cost, vehicle A is the best bus option. If the requirements of the system can be met with vans, then vehicle D is a good option.

CURRENT TRENDS AND FUTURE VEHICLES: NEXT TEN YEARS

To properly assess the future maintenance requirements of, the demand for, and the supply of paratransit vehicles, it is necessary to look at current trends in both North

America and elsewhere. At present, the following observations can be made:

1. There is a trend toward smaller, lighter automotive vehicles (using substantial amounts of plastics) to reduce fuel consumption.
2. The interest in reducing fuel consumption is encouraging the use of more expensive diesel engines in passenger automobiles and light vans.
3. Some transit systems (e.g., Ottawa and Calgary) are replacing the gasoline engines in their small (30-passenger) buses with diesel engines to improve fuel consumption.
4. There is a trend toward the use of larger capacity vehicles by all types of operators (i.e., transit systems are using articulated buses and taxi operators are using vans and buses) to improve labor productivity.
5. Federal governments in both Canada and the United States are encouraging investment in less capital-intensive public transportation.
6. There is a trend toward more leasing of vehicles by public operators in Canada and by private operators in both Canada and the United States.
7. Battery-powered buses are being tested (5, 6).
8. Transit managers are more willing to buy higher quality, higher cost buses because of numerous problems with lower quality vehicles.

Other factors affecting the future development of vehicles include

1. The continuing pressure for public transportation for the disadvantaged,
2. The cost of new technology (which often increases at a faster rate than the labor cost of public transportation),
3. The decrease in the number of companies developing a new technology as the technology matures (e.g., downtown people-mover manufacturers and small bus manufacturers),
4. The consolidation of taxi operations by brokers who finance the vehicles only and supply the communication system for a fee, and
5. Deregulation of taxis [which could result in faster replacement of vehicles (7)].

These observations lead to the following predictions:

1. The paratransit vehicle of the future will probably be a multipurpose, small, diesel-powered bus with a nominal seating capacity of about 24 persons.
2. This vehicle will offer an optional package to accommodate wheelchair passengers mixed with semiambulatory and ambulatory passengers.
3. The market for paratransit vehicles is small but growing; other uses (such as recreational and limousine service) will continue to affect the production of vehicles during the next 10 years.
4. The production of third-generation vehicles by fewer companies will reduce maintenance problems.

Table 1. Cost analysis.

Vehicle	Capital ($)			Operating ($)		Total ($)
	Initial	Financing	Spare Allowance	Fuel	Maintenance	
A	5000	2500	400	1700	10 000	19 600
B	5000	1250	750	6000	16 000	29 000
C	4000	800	650	4000	14 000	23 450
D	3500	525	425	4000	10 000	18 450

5. The cost of vehicles will continue to increase because of more expensive power plants and specialized hardware for handicapped persons.

ACTION REQUIRED

Maintenance Data Base

A standardized data base of paratransit vehicle performance is needed. The difficulty with the excellent vehicle-appraisal system described by Chaput (4) is that the vehicles are compared within the operators' own fleets only. Because of the multiplicity of vehicles in paratransit service today, often in very small fleets, it is rarely possible to make valid comparisons. It would therefore be useful to have a national review of vehicle experience by type and model, similar to that done by the state of Michigan (2).

Taxi Regulations

Another area requiring attention is the trend toward the use of smaller taxi vehicles. Some cities are already controlling the minimum size by using bylaws, but as automobile sizes continue to decrease, it would seem reasonable to open the size limitation to permit microbuses or vans to operate as taxis. A standardization of regulations is desirable (8).

New Vehicle Designs

An assessment of the potential for the development of a high-quality small vehicle is not encouraging. In Canada, Flyer Industries of Winnipeg, Manitoba, received funding from the province and the Canadian federal government to develop a prototype small bus about 4 years ago. The design was completed and the bus about 90 percent developed when the project was abandoned. Other large-vehicle manufacturers have expressed little or no interest in the small bus market.

In contrast, the variety and quality of vans available for paratransit services is steadily increasing. This is due to the increasing volume market for personal use.

There may be greater potential for the development of a better taxi. The International Taxicab Association has advised the Urban Mass Transportation Administration of the need for a standard specification for taxi vehicles, and prototype vehicles have been built (9). Such a specification could encourage industry to build a larger, more accessible taxi vehicle that would serve a high-volume market including many paratransit applications.

The role of the taxicab is changing (10). Several applications of taxis for organized paratransit services have already been tested (11, 12); several systems have been designed and approved for implementation in Canada (13, 14, 15); and the use of taxis for the transportation of handicapped persons has been closely examined (16).

What is required now is the implementation, monitoring, and dissemination of experience to improve the credibility of paratransit services (17). Otherwise, a high-volume vehicle market will not develop. It is a paradox that system implementation is inhibited by bad experiences with the vehicles, and the limited application inhibits vehicle development (18).

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Information and Control Systems for Paratransit Services

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The current uses of information and control systems in paratransit services are reviewed, and new applications that are currently being developed are discussed. Thus far, the greatest use has been by the conventional transit and taxi industries for accounting, payroll, and limited management information. In both of these industries, the larger operators have recognized that the costs of automating these clerical functions are readily justified by the benefits. However, for many other functions, the questions of whether automation will produce benefits and whether the costs can be justified are still open. In several functional areas, most strikingly brokerage and pooling services, advances in computer technology and reductions in computer costs are already making a stronger economic argument for automation. At present, however, the ability of many of the more innovative applications of computer technology to paratransit to provide real economic advantages is unproven.

Information and control systems are central to most forms of paratransit because of the importance of managing, organizing, and assigning the vehicles that provide the transportation. Each type of service has different characteristics, and the appropriate type of information and control system also varies considerably. However, there are several important questions that must be addressed independently of the specific service being studied. These include

1. What are the benefits of using information and control systems?
2. Do these benefits justify the costs of implementation?
3. What are the major problems in using these systems?
4. What role should the federal government play in furthering appropriate uses?

This paper explores these issues by drawing on experience obtained from information and control systems already implemented or currently being developed.

The paper is structured around the following functions that might be performed by the information and control system of a paratransit service:

1. Customer information—responding to service enquiries from the public and service inventory;
2. Operations planning—planning the transportation system;
3. Operations control—monitoring and controlling the operation of the system;
4. Maintenance support—parts inventory, planning fleet maintenance, and monitoring vehicle performance;
5. Management information—monitoring and reporting on system performance; and
6. Accounting—including payrolls and general ledgers.

In general, any information and control system will perform only a small subset of these possible functions; indeed, for most services some of them are not even required. Table 1 presents a matrix of these functions, indicating past, current, or planned use for each type of