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The Exceptional Service Of Driverless Metros

1997

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Automated People Movers can be classified on the basis of scale as "architectural", institutional", and "mass transit". The paper examines mass transit applications in both America and overseas, with emphasis on experience in France, Great Britain, Copenhagen, Canada, and Japan. The benefits of automation are discussed.

Automated People Movers, like ancient Gaul, can be divided into three parts. First, there are small APMs built entirely within a single architectural complex. They are implemented "internally" -- for example, within airports and casinos. The APM is owned and operated by the same entity that owns and operates the larger facility. From the owner's perspective, APMs are similar to moving walks, escalators, and elevators. At the end of 1998 there were 91 APMs operating around the world, and over half of them - most of the airport and leisure systems -- are of this "architectural" scale. These are shown in Table 1.

Secondly, there are APMs which are referred to as "institutional". They generally cross property lines and link distinctly separate buildings. They are open to the general public. In many, but not all cases, fares are charged. Institutional APMs are not, however, run by the local public transit authority. Instead, the owner may be a hospital, a university, a zoo, a private real estate developer, or a shopping center. Twenty-one such "institutional" APMs exist.

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Table 1. Operating APMS - 1998

In Airports			
Atlanta	Hong Kong	Miami	Seattle-Tacoma
Chicago	Houston	Newark	Singapore
Cincinnati	Kuala Lumpur	Orlando	Tampa
Dallas-Fort Worth	Las Vegas	Osaka-Kansai	Tampa-parking
Denver	Lond.-Gatwick	Paris-CDG	Tokyo-Narita
Frankfurt	Lond.-Stansted	Pittsburgh	
Leisure Settings			
Bellagio (Vegas)	Helsinki Linnanmaki(Fin)	Primm (NV)	
Bronx Zoo (NYC)	Jakarta Cult. Pk. (Indo)	Serfaus, Austria	
Busch Garden (VA)	Lotte World (Korea)	Shenzh. Pk. China)	
Cal Expo	Magic Mt. (CA)	Sun City (S. Afr.)	
Chester Zoo (UK)	Mammoth Mt. (CA)	Whiskey Pete (NV)	
Circus-Circus: Vegas	Mudd Island (TN)		
Circus-Circis: Reno	Miami Zoo (FL)		
Disney World (FL)	Minnesota Zoo (MN)		
Hersheypark (PA)	Mirage-Treas. Isl, (Vegas)		
Institutional			
Belfast Mall (UK)	Hiroshima Skyrail (Jap)	Pearlridge mall (HI)	
Detroit DPM (MI)	Las Colinas (TX)	Bara mall (Rio, Brazil)	
Dortmund Univ.(Germ)	London Docklands (UK)	Senate Subway (DC)	
Duke Hospital (NC)	Miami Metromover (FL)	Sydney HarbLink (Aus)	
Getty Center (CA)	Morgantown PRT (WV)	Taejon (Korea)	
Haifa Incline (Isr)	Mystic Center (MA)	Villepinte (Paris)	
Harbour Island (FL)	OrlyVAL (Paris)	Ziegenhain Hosp. (Ger)	
Public Transport			
* Ankara, Turkey	Kuala Lumpur, Malay	Taipei, Taiwan	
* Chiba, Japan	Laon, France	* Tokadai, Japan	
* Hiroshima, Japan	Lille- 1, France	Tokyo, Japan	
* Ina (Omiya), Japan	Lille- 2, France	Toulouse, France	
Jacksonville (FL)	Lyon, France	Vancouver (Can)	
* Kita Kyushu, Japan	Osaka, Japan	Yokohama, Japan	
Kobe Port, Japan	Paris Meteor, France	* Yukarigoaka, Japan	
Kobe Rokko, Japan	* Scarboro, Tor. (Can)		

* indicates operations with "drivers" are retained on board. (*Trans21*, various issues)

Metros: Sans Drivers

The third category of APMs, of which there are twenty-three, is mass transit. This is the focus of the remainder of this paper. Transit-scaled APMs are public transport systems using *driverless trains*. To the general public, they are variously perceived as "metros", "subways" or "rapid transit". In France they are known as the *VAL*, and more recently as Paris's *Meteor*. Like all true metros, APMs require completely segregated trackway, or right-of-way. Metros are often thought of as equivalent to underground rail, but they often have elevated and protected at-grade sections in outlying districts.

If a metro has enough electronic intelligence to operate without drivers, then it is an APM. No fully automated line-haul system operates in the United States. Downtown circulators in Detroit, Jacksonville and Miami do function as mass transit, but they do not serve radial corridors with line-haul service as is typically the case for metros. Overseas, driverless metros operate in fifteen cities, shown in Table 2. Seven more were underway in the fall of 1998.

Over the last two decades, the American Public Transit Association (APTA) has shown only marginal interest in "Automated Guideway Transit". AGT is a term for transit-scaled APMs left over from the 1970s when the U.S. government funded developmental programs in this area. APTA's AGT Committee was inactive through the most of the 1980s and early 1990s. Only recently has it become active, publishing an attractive booklet last year. (APTA, 1998)

Outside the United States, driverless metros have been more successful. The influential Brussels-based *Union Internationale des Transports Publics (UITP)* in early 1997 published a summary and assessment of this limited but impressive experience. (UITP, 1997)

The major finding of the *UITP* Committee that authored the report is that significantly more frequent, reliable and economic rapid transit service is within our technological reach. Driverless transit operations make good economic sense. Contrary to labor concerns about employment security, driverless metros can provide more meaningful career opportunities for transit workers in more cost-effective services with great growth potential in the twenty-first century. This and other secondary benefits are attainable.

Table 2. Driver-Free Metros - Winter 1999

City	Opening Year	Cost ($b)	Supplier	Comment
Kobe Portliner	81/82*	~0.2	Kawasaki	Elevated distributor
Osaka	81/93	~0.2	Sumitomo	Elev. distributor
Lille -1	83	0.3	Matra	Underground/elev.
-2	89	0.6	"	"
-3	99	0.5	"	"
Vancouver-1	86	0.9	Bombardier	Elev./underground
-2	02	1.1	"	Elevated (branch)
Yokohama	89/93	0.4	Mitsu/Niig.	Elevated
Laon (France)	89	0.03	Poma-Otis	Cable mini-metro
Kobe Rokkoliner	90	0.3	Kawa/Mitsu.	Elev. distributor
Lyon- Line D	92	1.0	Matra/Altsom	Underground
Toulouse -1	93	0.8	Matra	Elev./underground
-2	02	0.8	"	"
Hiroshima	94	0.8	Niig/Mitsu	Elevated
Tokyo Yurikamone	95	1.1	Jap.Consort.	Elevated
Taipei	96	0.9	Matra	Elevated
Ankara	98	0.7	Bombardier	Mostly underground
Paris Meteor	98	1.1	Matra/Alstom	Underground, extensions
Kuala Lumpur- 1	98	0.8	Bombardier	Elevated
-2	00	0.5	Hitachi	In mega-building
Copenhagen	00	0.7	Ansaldo	Elev./ underground
Rennes (France)	01	0.6	Matra	Underground
Singapore	02	2.9	Alstom	Underground
Monza (Italy)	02	0.1	Poma-Otis	Elevated
Turin	02	0.8	Matra	Underground
Tokyo- Toneri	03	0.6	Jap.Consort.	Elevated

In addition, the following potentially driver-free systems operate with train attendants: Ina (82), Yukarigaoka (83), Kita Kyushu (85), Chiba (88), and Nagoya/Tokadai (91) in Japan; and Toronto/Scarborough (85). Downtown circulation systems operate without drivers in Miami (86), Detroit (87), Sydney (88/90), and Jacksonville (89). An incline in Haifa now operates as transit in automatic mode.

"A totally automated metro is less expensive in both investment and on-going maintenance costs than a metro system with a driver. It also offers a much more attractive service quality." (p. 12) So concluded the Working Group on the Total Automation of Metro Systems of *UITP*'s International Metropolitan Railways Committee.

Experience with Driverless Metros

What is the basis of these revolutionary conclusions by the *UITP* Working Group? First and foremost, it is the real operating experience of eight driverless metros. Four of them are in France: Lille's *VAL* 1 which opened in 1983, the second Lille *VAL* which followed in 1989, Lyon's *Ligne D* which went into service in 1992, and Toulouse's *VAL* (1993). The *UITP* survey also includes two automated operations in Japan: Osaka, which opened back in 1981, and the more recent Tokyo Waterfront line (1995).

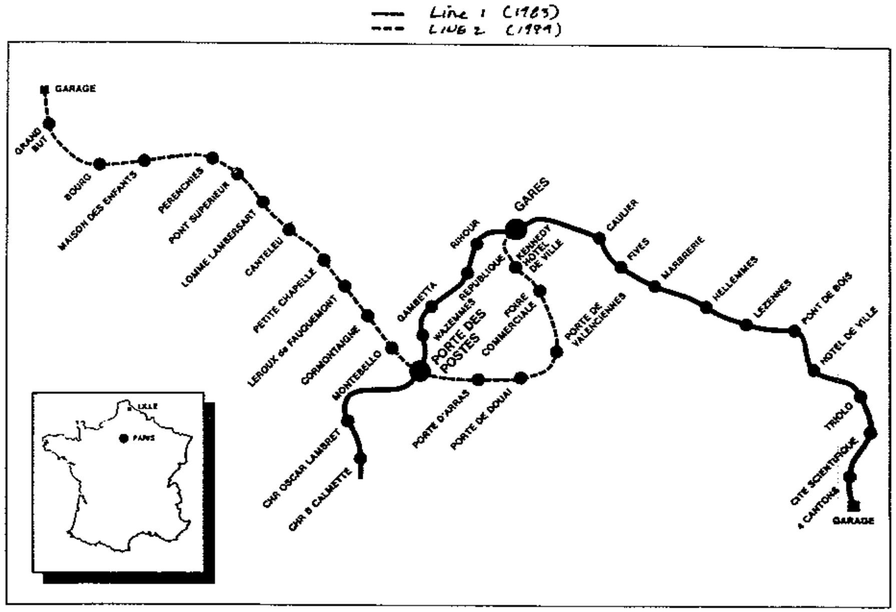

Figure 1. Lille, France has two driverless metro lines intersect at two stations. A third line is underway. (courtesy of Matra Transport)

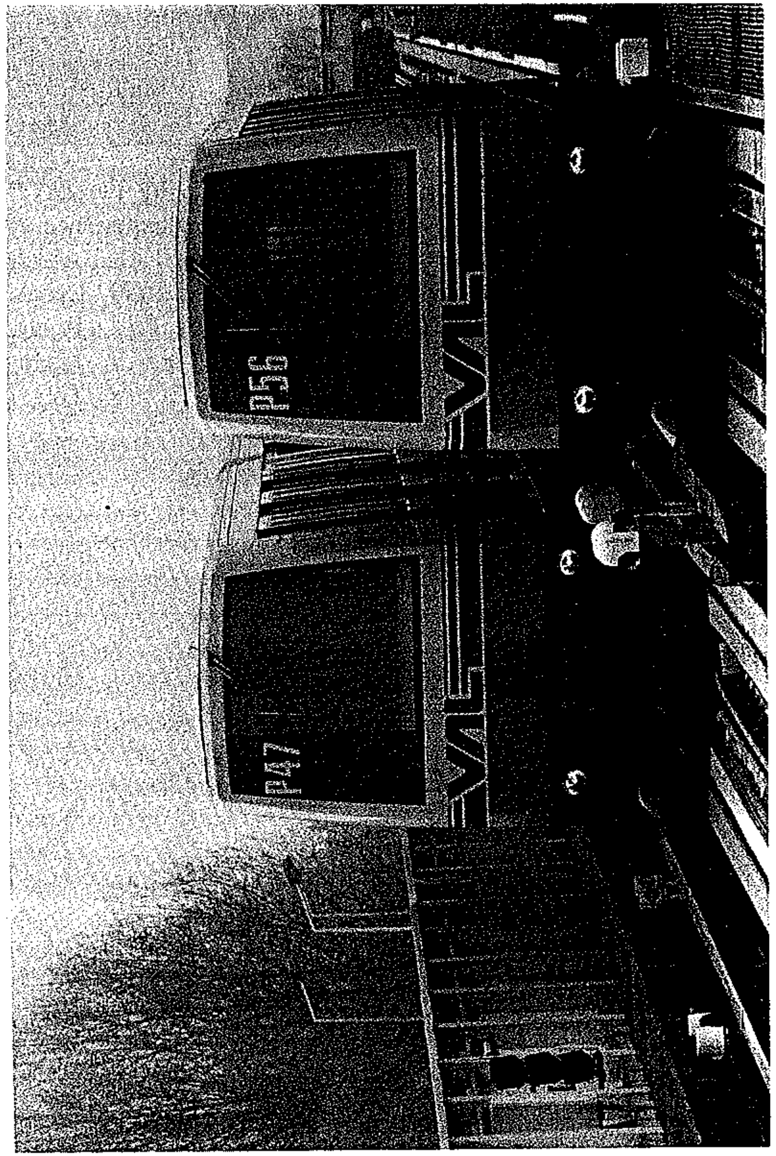

Figure 2. Vehicles for Lille's driverless *VAL* metro were designed to be narrow to reduce tunneling costs. More frequent runs mean capacity can still be high. (courtesy of Matra Transport)

Two other two driverless metros are in the *UITP* database. One is the complex London Docklands Light Railway which fitfully started carrying passengers in 1987. The other is in North American, the Vancouver SkyTrain which began service in 1986. The *UITP* report also describes (but obviously does not include operating statistics for) two projects that opened in 1998. One is Paris's new Meteor line implemented with major participation from Matra and Alstom. The other is a Bombardier-supplied line in Kuala Lumpur, Malaysia. The report also describes plans to retrofit driverless operation on Berlin's U5 subway line.

Impressive Safety Records

UITP's *Driverless Metro* report presents hard-to-find data on passenger injuries and deaths that have occurred on these eight driverless metro installations. The results are summarized in Table 3. Overall, it is a very impressive record of safety. There has not been a single system-induced passenger fatality.

Two numbers do stand out. First are the 22 deaths that occurred in Vancouver. Nineteen of them were suicides. This problem could be significantly reduced or eliminated by the installation of station walls and doors that separate waiting passengers from the track. Station walls are common on *VAL* metros and in airport APMs.

Three other fatalities occurred on the Vancouver SkyTrain: a woman fainted and fell between two cars, a man fled police onto the track and a drunk passenger ventured onto the track. Single fatalities on the Docklands and Lyon systems also involved drunken passengers who ventured onto the track. These systems also are without station doors.

The second shocking number in Table 3 is the 200 injuries reported for the Osaka New Tram in Japan. On October 5, 1993, a serious accident occurred due to a failure in the automated controls. A crowded rush-hour train crashed into a buffer. About 200 of the 250 passengers were injured, 46 of them "badly". Fortunately there were no casualties. Service was suspended for some five weeks. Upon re-opening, attendants were aboard trains.

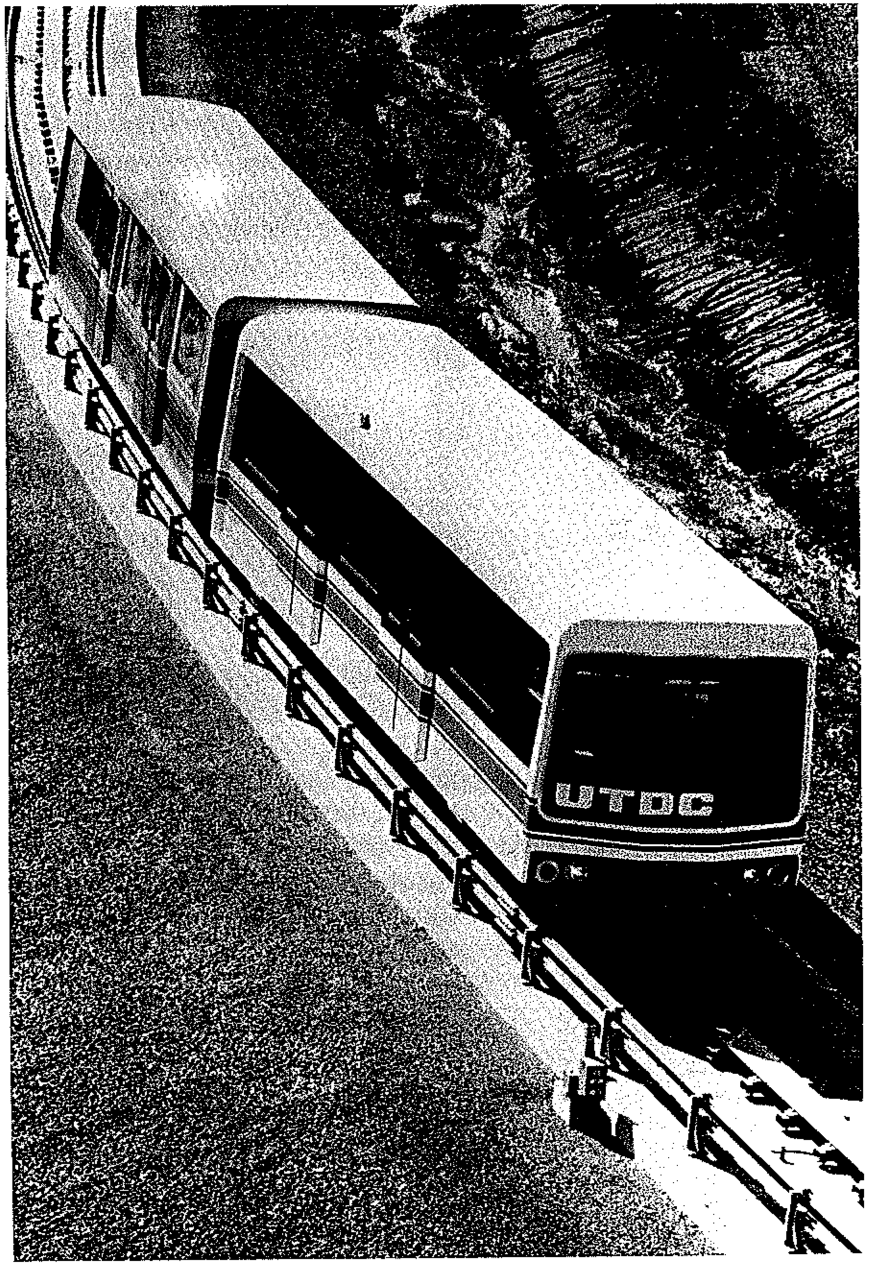

Figure 3. The Vancouver SkyTrain uses UTDC hardware, now supplied by Bombardier.

Table 3. Safety Records of Line-Haul APMs
(no. incidents from start to 1996)

AGT System	Fatalities	Injuries
Lille 1	0	3
Lille 2	0	0
Docklands	1	44 (minor)
Lyon	1	10 (minor)
Osaka	0	200
Tokyo	0	0
Toulouse	0	3 (door)
Vancouver	22	3

Source: *A Better Quality Service at the Lowest Cost: Driverless Metros* (Brussels, UITP, 1997).

Benefits and Side-Benefits

The Osaka accident and Vancouver's suicide problems notwithstanding, the safety and reliability records of driverless metros are very encouraging. Indeed, there is evidence that they are significantly safer than conventionally driven rail transit.

Full automation makes frequent service not only safer, but also more economic and reliable. More frequent service is very attractive to the public. It reduces wait times which are especially unpleasant to riders. The same is true of uncertainty. According to the UITP findings, in line-haul APMs that have station doors, service availability averages 99.7%. Without doors it is a bit lower, but still far *superior* to conventional metros with drivers.

Full automation also allows very precise and very rapid *adjustments* to real-time transit operations. This is extremely important to transit service providers and the riding public. Indeed, the *UITP* Working Group sees this as a "formidable opportunity" for transit operators to attain "exceptional service quality" (p. 11).

In conventional metros, drivers are isolated in their compartment. They often are quite bored by .the monotony of their working days. In APMs, human operators are reassigned from the driver compartments into a control center which is amply equipped to provide extensive and instant operating information on the whole system. This control staff easily communicates with passengers in trains and stations as well as maintenance crews and security staff. They can quickly re-organize service and respond to unexpected conditions.

As driverless metro experience grows, working conditions evolve. Two management trends are clear. In APMs, human resources are more rationally deployed within more sophisticated communications infrastructure and management. Secondly, there is more direct communication between staff and passengers. This has created and will continue to create new kinds of staff positions that require technical skills using communications hardware and software. Other APM staffing positions entail direct contact with the public.

Fully automated metro operation also brings early savings in the design and construction of the transit facilities. No matter what level of capacity is forecast, more frequent but *smaller* trains can satisfy the requirement. Shorter trains mean smaller stations, and therefore lower station costs. Other design economies are realized by the reduced need for sidings to hold trains ready for service.

Copenhagen's New Minimetro

One of the urban APMs included in the UITP survey but not yet with operating experience is a "minimetro" underway in Copenhagen. The Danish legislature in 1992 created a public authority to plan and oversee the development of a modern commercial and residential district on reclaimed land on an island near the center of Copenhagen. Planning work, begun in 1993, focused on an advanced, automated link to the city center. Construction began in 1997.

The $750-million first phase is about 11 kilometers in length (5km in tunnel) with 11 stations. Much of the cost is for tunneling and guideways. The system supply contract with Ansaldo is for about $293 million. Design capacity is 12,000 passengers per hour per direction. Much of the funding comes from sale of prime development rights on Orestad island. The rest will come from anticipated operating profits.

A thorough comparison of conventional trams, light rail and an automated minimetro was carried out, including a risk analysis of passenger fatalities. The Danes concluded that the minimetro will provide

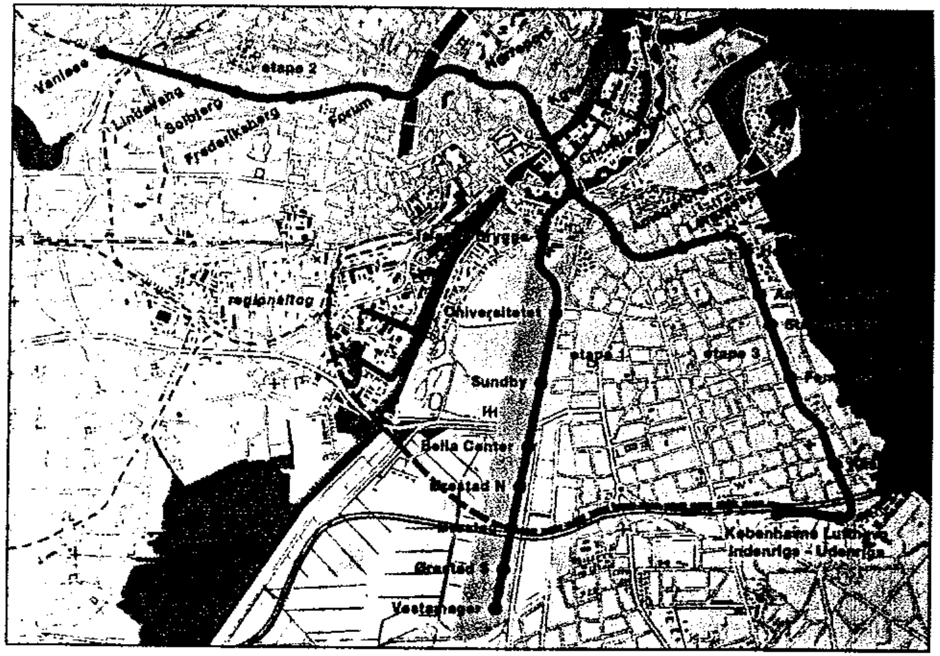

Figure 4. Copenhagen's minimetro will connect major new development along its southwestern branch to and through the city center. The eastern branch will serve the airport.

the best service, attract more riders and yet have fewer accidents[1]. These findings are summarized in Table 4. The minimetro will initially be more expensive but ultimately far superior. Service is anticipated to begin in the year 2000 -- the year after the 7th International APM Conference, to take place in Copenhagen in May of 1999.[2]

There are many lessons to be learned from driverless metros and Copenhagen's planning decisions. Full automation of guideway transit brings significant benefits to line-haul rail transit at reasonable costs. This is welcome news for the mass transit industry, long plagued by continuing market losses to the convenience of the automobile.

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[1] "How Copenhagen Chose an Automated Minimetro System: A Comparative Analysis of 3 Mass Transit Systems" by Morten Sondergaard, in *APM96: Proceedings of the 5th International Conference on Automated People Movers* (AFCET, Paris, 1996).

[2] For details, contact APM'99, c/o DIS Congress Service at (45) 4492-4492; fax (45) 4492-5050, or email *dis-con@inet.uni-c.dk*.

Singapore has decided to make its new northeast rapid transit line driverless. This is to open in 2002. It is reasonable to expect more driverless metro projects and the conversion of existing rail lines to full automation as we move into the 21st century.

Table 4. Cross Modal Comparison (Orestdad Minimetro, Copenhagen)

	Minimetro	Tram	Light Rail
Fatalities/year	0.3	1.1	1.0
Year 2000 ridership	28m	5m	20m
Capital cost*/ pax-km/year	100	163	106
Internal rate of return	2.4%	0.5%	2.0%

* *in millions of Danish krone, 1995.*

Source: Morten Sondergaard, "How Copenhagen Chose an Automated Minimetro System", in *APM96: 5th International Conference on Automated People Movers* (Paris, AFCET, 1996), pp. 461-471.

References

APTA, "Automated Guideway Transit", Washington, D.C. 1998.
Trans21 Newsletter, Boston, Massachusetts.
UTTP, "A Better Quality at the Lowest Cost: Driverless Metros", Brussels, 1997.

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The Supply Side Of The Automated People Mover Market: A Spectrum Of Choices

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A survey of the supply side of the Automated People Mover (APM) market over the past ten to fifteen years shows some significant trends. In the nineteen eighties, suppliers concentrated on designing, developing, and marketing unique technologies. Thus, each supplier tended to specialize in a single technology, with some variations in size and capacity. With the present growth of the APM market, several APM suppliers have developed, either through mergers or acquisitions, a more diversified range of technologies to meet a variety of system requirements in terms of capacity, service and budget considerations. As a result of this trend, the transit industry now has a full range of technologies that are well proven and capable of meeting the different needs, special operational requirements, and budgets of its potential clients.

Introduction

Some significant trends are apparent in the evolution of the supply side of the APM market over the past ten to fifteen years. In the past, the market was mainly comprised of suppliers who tended to specialize in a single technology, but today there are several APM suppliers whose diversity enables them to offer a range of technologies that are well proven and capable of meeting the needs of their clients. We chose to examine these recent trends from the perspective of the available technologies and the backgrounds of the companies that offer them.

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