MEDIUM CAPACITY GUIDED TRANSIT SYSTEMS

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Contents

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1. Increasing Need for Medium Capacity Transit Systems

- *Large gap between Bus and Metro Systems*
- *Services which Buses or Metros can not provide*
- *Need for higher performance systems than Buses at lower cost than Metros*

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- *Medium-capacity transit modes*
  - · *Bus Semirapid Transit - BST*
  - · *Light Rail Transit - LRT*
  - · *Automated Guided Transit - AGT, rubber-tired or rail*
- *Human factor in cities: transit is needed that has a strong distinctive image, but can penetrate inner city and pedestrian areas*

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- **Importance of Right-of-Way (ROW) Separation for System Performance**

- Definitions of ROW Categories:
- Streets, mixed traffic - C;
- Longitudinally separated - B; and
- Fully grade-separated - A.

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- Separated ROW, B and A, provide high performance and competitiveness with auto travel
- Comparison between ROW B and A:
- ROW B requires lower investment, has greater diversity in alignment geometry and locations
- ROW A allows higher performance and full automation

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- **Light Rail Transit - the Dominant Medium Capacity System**

- Comparison of LRT with buses

  · *LRT is easier to separate and thus provide faster and more reliable service*

  · *LRT has better performance, higher capacity and lower operating cost*

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· *With electric propulsion, LRT produces no air pollution and much lower noise*
· *LRT has a stronger image, it is popular and attracts more riders*
· *LRT contributes to livability of the city*
· *Buses require lower investment and need fewer transfers*

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- Comparison of LRT with Metro systems
  - · *LRT requires substantially lower investment*
  - · *LRT can penetrate high-density and pedestrian areas*
  - · *LRT can be built incrementally*
  - · *Metro has a higher capacity, speed and reliability*
  - · *Metro has a strong positive impact on shaping the city*

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- Planning, technology and operational innovations in LRT since the 1950s
  - · *Diversity of LRT: from Tramways to High-Performance Light Metro*
- Light Rail Rapid Transit – LRRT
- Automated LRRT

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4. Review of LRT Applications

- Developments of LRT by region:
  - *Europe: Germany, Belgium, Switzerland, Austria, France*
  - *North America: USA, Canada, Mexico*
  - *Developing countries: Tunis, Egypt, Philippines, Hong Kong*
  - *Japan working on catching up in LRT development*
  - *Korea: any progress so far? Inadequate understanding, failure to use LRT*
- Nine types of applications of LRT

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- **Automated Guided Transit – AGT (or APM)**

- The beginnings: theoretical concepts: AGT, including GRT and PRT
- Theoreticians and idealistic inventors introduced many incorrect concepts: from monorails to PRT "systems"
- Real world experience eliminated PRT, modified GRT into practical AGT systems
- Development of Westinghouse, Airtrans, VAL and other AGT systems

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- Two categories of AGT: airport and other shuttles, and transit systems
- AGT as transit:
  - *North America: Miami and Detroit*
  - *VAL in France: Lille, Toulouse, Orly, Rennes, and in Taipei*
  - *Japanese AGT's: Kobe, Osaka, Yokohama*
  - *ALRT systems - AGT on rails: Vancouver, London Docklands*
- Automated metros: Lyon, Paris, Berlin

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6. Comparison of LRT and AGT

- Experiences in mode selection in USA, French and Italian cities, Taipei
  - *Reasons for much wider use of LRT than AGT:*
  - *Diversity in alignment capability, vehicle types and performance*
  - *Ability to fit into urban environment*
  - *Much lower investment and somewhat lower operating costs*
  - *Rail systems are not proprietary - multiple suppliers prevent excessive 14supply costs*

These advantages usually greatly outweigh the advantages of automated systems

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- **Technical Evaluation of Transit System Concepts**

- Transit system planning should be based on functional definition, then proceed to selection of mode technology
- Major components that should be planned for guided modes are:
  - *Right-of-way categories: ability to use not only A, but also B or C, may be a great advantage, resulting in much lower investment costs*
  - *Which vehicle and train sizes should be used?*
  - *Rail or rubber-tired systems?*
- What role should the system have in human-oriented city and urban design

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- Advantages and disadvantages of fully automated transit systems:

Would the advantages of automated systems be worth their much higher cost, inability to be integrated in urban areas and other problems?

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- **Comments on Transit Developments in Korea**

- Present conditions and needed improvements: *Seoul, Busan and medium-size cities*
- Medium capacity systems neglected: *they are not used*
- Importance of economic efficiency; *need for networks, not only single lines*

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- Expanded diversity and roles of rail transit should be utilized
- Automation is a secondary aspect: *it is method of operation, not a determinant of modes*
- Generic systems should be favored over proprietary systems with single suppliers which carry considerable risks
- "Family of rail transit modes" should be introduced.

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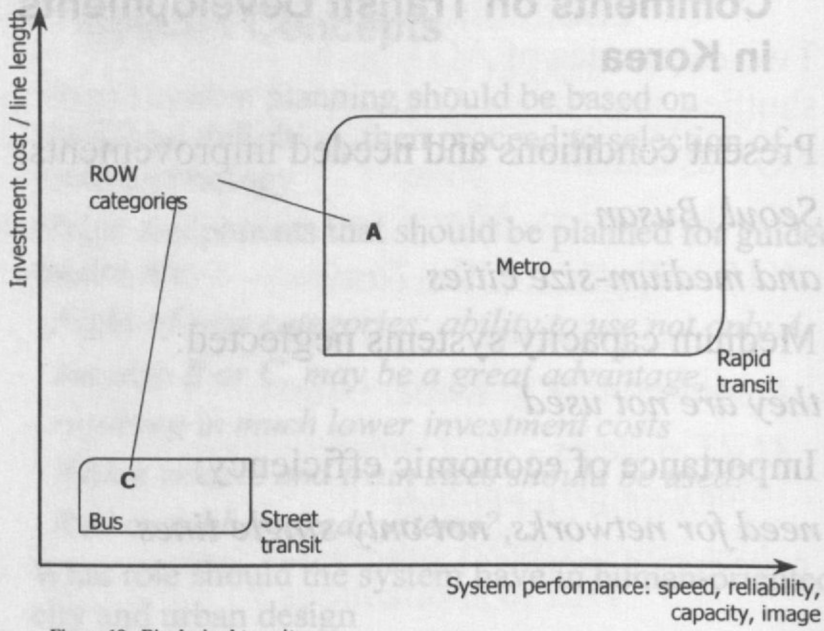

Figure 19. Bipolarized transit

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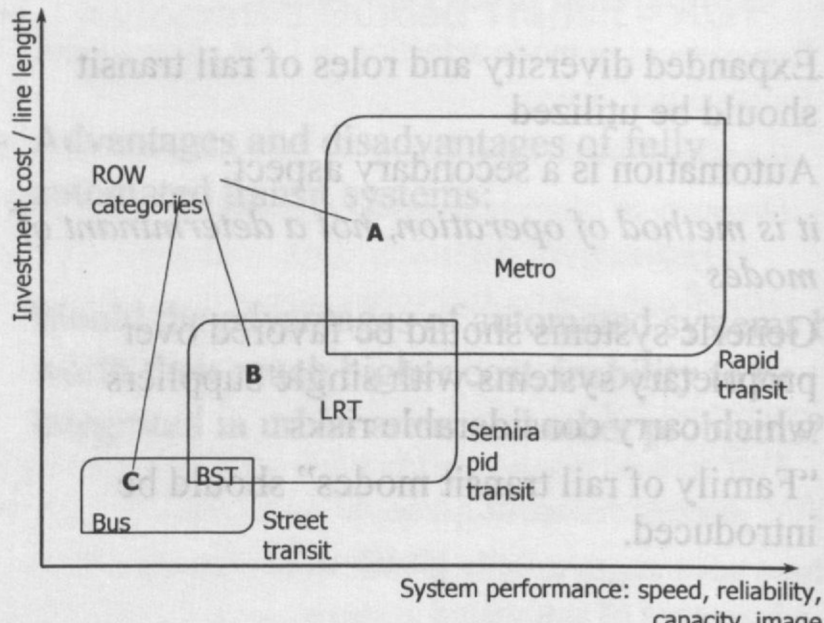

Figure 20. Intermediate systems "filling the gap" between street transit and metros

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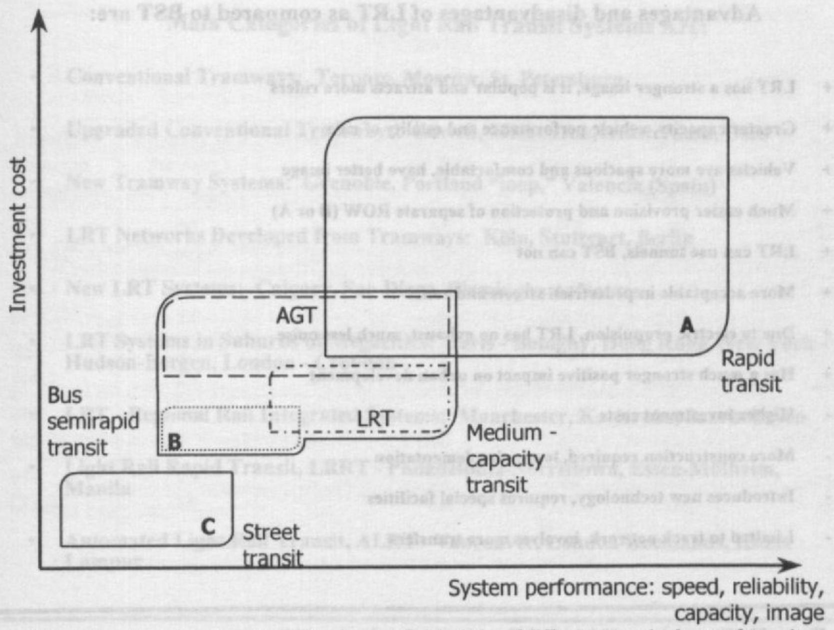

Figure 21. Investment cost / performance characteristics of different generic classes of transit modes

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Compared to fully-separated ROW, Category A, partially separated ROW, Category B, gives transit systems the following advantages (+) and disadvantages(-):

- \+ **Much lower investment cost**
- \+ **Much more diversified alignment - boulevard and street medians can be used**
- \+ **It can penetrate into pedestrian zones and enhance their livability**
- \+ **Stations are smaller, simpler and more pedestrian-friendly**
- \- **System performance - speed, reliability, capacity - is lower**
- \- **Operational safety is lower (no positive fail-safe signal control)**
- \- **May involve complex traffic regulation**

Figure 22. Investment cost / performance characteristics of different generic classes of transit modes

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Advantages and disadvantages of LRT as compared to BST are:

- \+ LRT has a stronger image, it is popular and attracts more riders
- \+ Greater capacity, vehicle performance and quality of ride
- \+ Vehicles are more spacious and comfortable, have better image
- \+ Much easier provision and protection of separate ROW (B or A)
- \+ LRT can use tunnels, BST can not
- \+ More acceptable in pedestrian streets and zones
- \+ Due to electric propulsion, LRT has no exhaust, much less noise
- \+ Has a much stronger positive impact on urban development
- \- Higher investment costs
- \- More construction required, longer implementation
- \- Introduces new technology, requires special facilities
- \- Limited to track network, involves more transfers

Figure 23. Comparison of Light Rail Transit with Bus Semirapid Transit

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Major innovations in LRT in recent decades include:

- Consolidation of networks into fewer, but higher quality lines (tramways to Light Rail Transit)
- Systematic replacement of ROW C by ROW B and A
- High-quality tracks and switches prevent any noise production
- Articulated vehicles, 1-4 car trains
- Low-floor vehicles
- Self-service fare collection
- 1-4 car trains have 8 to 32 door channels for simultaneous boarding/alighting
- Integration of tunnel, surface and aerial alignments on the same line
- Intermodal integration with buses and metros
- Operation of LRT in central cities in pedestrian zones
- Integration (track sharing) of LRT with Regional Rail lines for services to suburbs

Figure 24. Major innovations in LRT since the 1950's

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Main Categories of Light Rail Transit Systems Are:

- **Conventional Tramways: Toronto, Moscow, St. Petersburg**
- **Upgraded Conventional Tramways: Zürich, Melbourne, Amsterdam, Oslo**
- **New Tramway Systems: Grenoble, Portland “loop,” Valencia (Spain)**
- **LRT Networks Developed from Tramways: Köln, Stuttgart, Berlin**
- **New LRT Systems: Calgary, San Diego, Birmingham, Nantes**
- **LRT Systems in Suburbs of Megacities: Paris - Bobigny, Hong Kong, New York - Hudson-Bergen, London - Croydon**
- **LRT - Regional Rail Integrated Systems: Manchester, Karlsruhe, Saarbrücken**
- **Light Rail Rapid Transit, LRRT - Philadelphia-Norristown, Essen-Mülheim, Manila**
- **Automated Light Rail Transit, ALRT - Vancouver, London-Docklands, Kuala Lumpur**

Figure 25. Nine categories of LRT/Tramway systems and their applications

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	System – City	Manufacturer ? Country	Length L [m]	Width W [m]	Gross Area A_g[m²]	Capacity Seats / Total a	Gross wgt W_g[kg] b	Power P [kW]	Wg/n_{ax} [kg]	P/W_t [kw/t]
A	Airtrans – Dallas/FW	LTV/Vought ?USA	6.48	2.24	14.52	16/40	8,150	56	4,075	10.47
B	ALRT – Vancouver	UTDC ? Canada	12.70	2.50	31.75	40/100	20,600	(LIM)c	5,150	(LIM)c
C	KCV - Kobe	Kawasaki ? Japan	8.00	2.39	19.12	20/62	14,840	90	7,420	8.57
D	M – Bahn	Siemens -Germany	11.80	2.30	27.14	?/70	12,700	(LIM)c	n.a.	(LIM)c
E	Morgantown	Alden/Boeing -USA	4.73	1.83	8.66	8/21	5,370	45	2,685	11.54
F	New Tram – Osaka	Niigata/LTV ? Japan	8.00	2.29	18.32	20/62	14,340	90	7,170	9.00
G	Skybus – Miami	Westinghouse Elec. ? USA	9.30	2.59	24.09	28/70	13,500	90	6,750	10.47
H	VAL – Lille	Matra ? France	12.50	2.06	25.75	34/86	19,870	240	9,935	17.33

a Assumed area per standee: 0.20 m². Capacity may vary due to different seating arrangements.
b Assumer weight per person: 70 kg.
c Propulsion by linear induction motor (LIM) which has different power characteristics than conventional electric motors.

Figure 26. Vehicle characteristics for selected AGT systems

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System – City	Types of Service	Headway (min/TU)	Frequency (TU/h)	Cars/TU	Car capacity (prs/car)	Offered capacity (sps/h)
• ALRT – Vancouver	Min Max	2.5 1.25	24 28	1 6	20 100	480 28,800
2. KCV ? Kobe	Min Max	2.5 2.0	24 30	6 6	10 62	1,440 11,160
3. New Tram – Osaka	Min Max	2.5 2.0	24 30	4 4	10 62	960 7,440
4. Skybus - Miami	Min Max	2.5 1.5	24 40	1 6	14 70	336 16,800
5. VAL – Lille	Min Max	2.5 1.25	24 48	2 4	17 86	816 16,512

Figure 27. Data for service / capacity computations of different AGT systems

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Compared to AGT, LRT has the following characteristics:

+ **LRT requires much lower investment cost**
+ **It has lower operating cost**
+ **LRT is not limited to ROW A only; it can utilize streets**
+ **LRT can fit into urban and pedestrian zones and enhance their attraction**
+ **Vehicles offer considerably better riding comfort**
+ **LRT has a good image and it is very popular as a symbol of the city**
- **LRT can not be operated automatically, unless it has only ROW A**
- **It has lower speed and frequency of service than AGT**
- **LRT has somewhat lower safety than AGT**
- **Its schedule can not be quickly adjusted to unexpected changes, as AGT**

Figure 28. Comparison of Light Rail Transit and Automated Guided Transit

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Rubber-tired guided as compared to rail transit systems have the following differences:

+ **Rubber tired vehicles allow more flexible alignment: sharper curves and steeper gradients - than rail vehicles**
+ **For small and medium-size vehicles design with rubber tires is simpler**
+ **Rubber tired vehicles produce less noise in curves than rail vehicles**
- **They are less stable and provide a considerably less comfortable ride than rail vehicles because of rail stability, larger size of rail vehicles and use of bogies**
- **Average vehicle weight is similar, but rubber-tired vehicles have greater rolling resistance and therefore use more energy**
- **Rubber tires produce more heat in tunnels and represent certain fire hazard**
- **Rubber-tired systems can be used on ROW A only; they can not cross any streets**
- **Their switching is slower, more complicated and takes more space; guideways can not cross each other**
- **Rubber-tired systems are more vulnerable to snow and ice**

Figure 11. Comparison of rail with rubber-tired guided transit

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Fully automated operation of transit vehicles and trains as compared to driver operated ones has these advantages and disadvantages:

+ **Very frequent operation of short trains is feasible even during off-peak periods**
+ **Quick adjustments of schedules to any changing conditions are possible**
+ **Driving regime can be optimized for all conditions**
- **Investment cost is much higher**
- **Lines can not go through streets, pedestrian or green areas**
- **Presence of a crew member has certain advantages for security, informing passengers, etc. For this reason some fully automated systems still place a crew member on the train**
- **Handling of emergencies is more difficult**
- **Mechanical and control systems are much more complex, require high-cost maintenance**
- **Operating cost is usually higher on automated systems**

Figure 12. Evaluation of fully automatic transit systems

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City / Line	Year	Train Length: Cars	Meters	Spaces	Crew Size	Operation – Event	Innovation
New York Subway	1904	6	108	1100	7	Driver + 6 Guards	
Paris Metro	1930?	5	71	750	2	1 Guard / Car -- 1 Guard / Train	2-Person Crew
Hamburg U-Bahn	1957	8	112	1100	1	Eliminate Guard	1-Person Crew +Platform Attendant
New York / Times Square Shuttle	1964	3	54	540	(1)	Driver Sitting	(1), ATO
London / Victoria Line	1968	8	128	1480	1	Driver Door Control	1 Person, ATO
Philadelphia / PATCO	1969	6	124	1200	1	Central Station Supervision	Unattended Stations
San Francisco / BART	1972	10	220	2160	1	Driver Door Control	1-Person, 10-Car Train

Figure 31. Historic development of automation of guided transit systems

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City / Line	Year	Train Length: Cars	Meters	Spaces	Crew Size	Operation – Event	Innovation
Dallas - Forth Worth / Airtrans	1974	2	13	80	0	ATO, ATS; Low Capacity	Automated Network in Airport
Morgantown	1975	1	5	21	0	ATO, ATS; Very Low Capacity	Automated Low-Capacity Transit
Atlanta Airport / Westinghouse	1980	3	36	420	0	ATO, ATS; Medium Capacity	Med. Capacity Automated Shuttle
Lille / VAL	1983	2	28	172	0	ATO, ATS	Automated Regular Transit
Vancouver / Skytrain	1986	4	51	440	0	ATO, ATS	Roving Driver-Attendant
London / Docklands LRT	1988	2	56	524	(1)	ATO, ATS	Driver-Attendant on Each Train
Lyon Metro Line D	1993	3	50	450	0	ATO, ATS	Fully Automated Metro
Paris Metro Line 14	1998	5	75	750	0	ATO, ATS	Fully Automated Metro

Figure 13 (cont). Historical development of automation of guided transit systems

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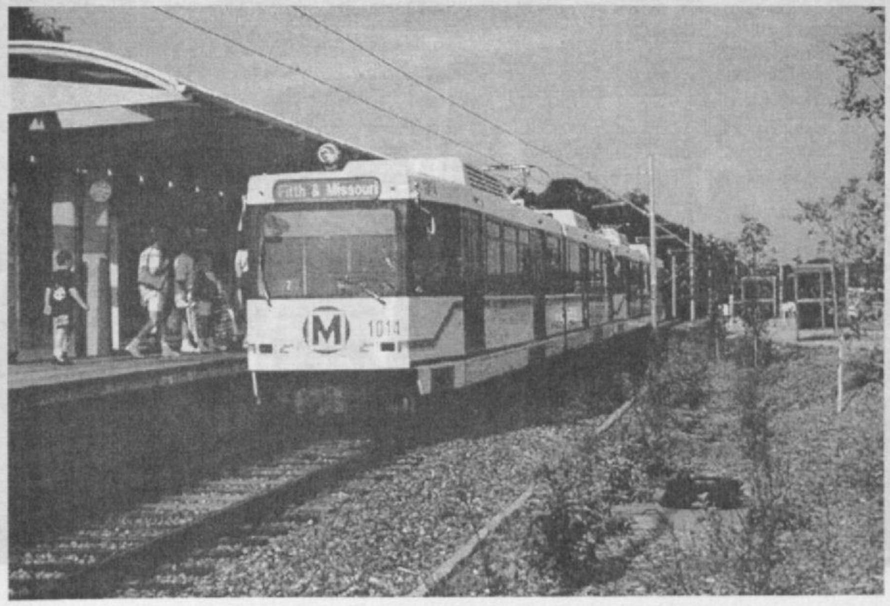

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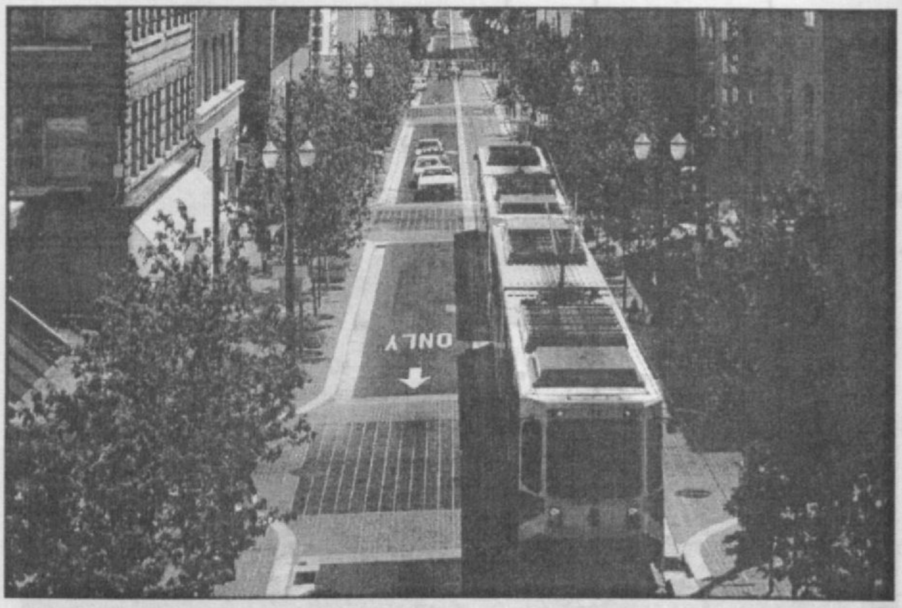

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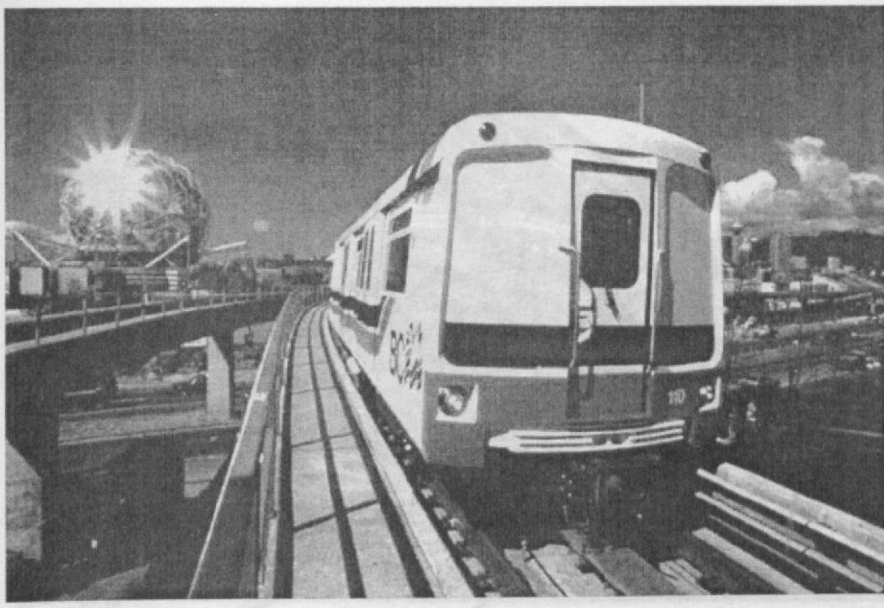

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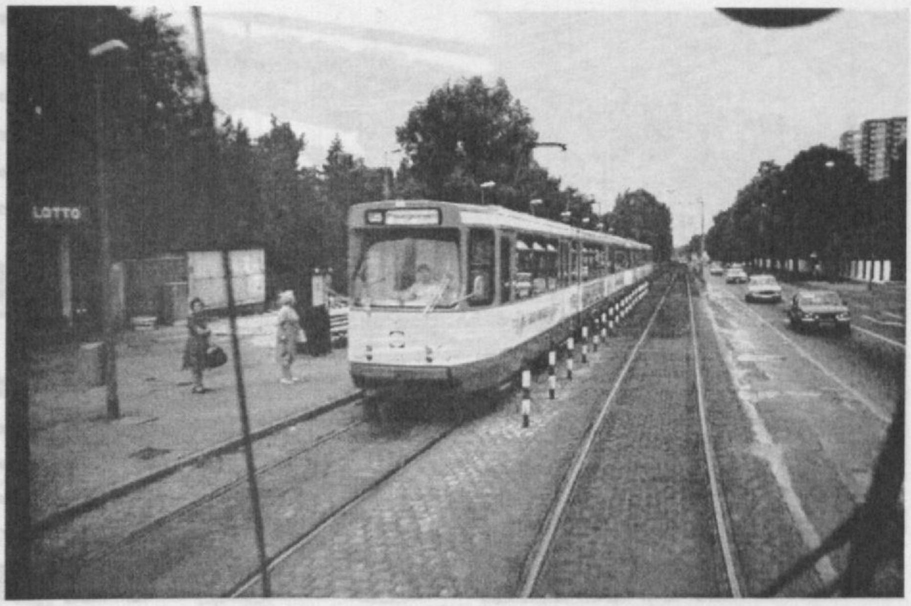

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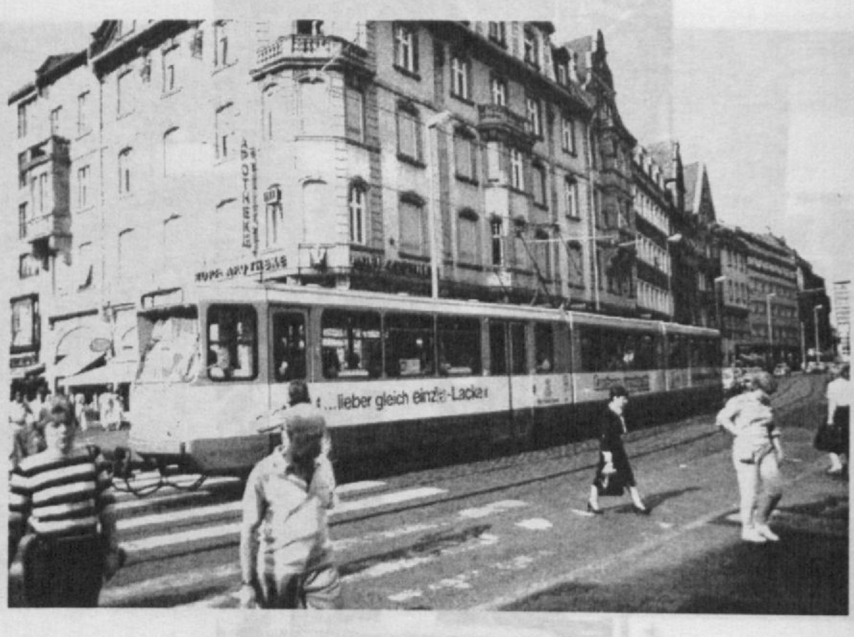

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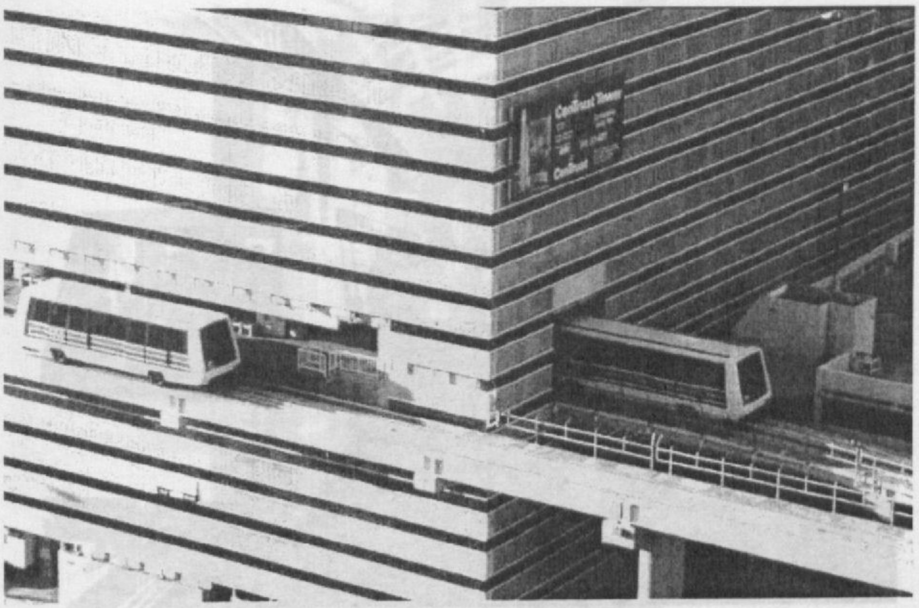

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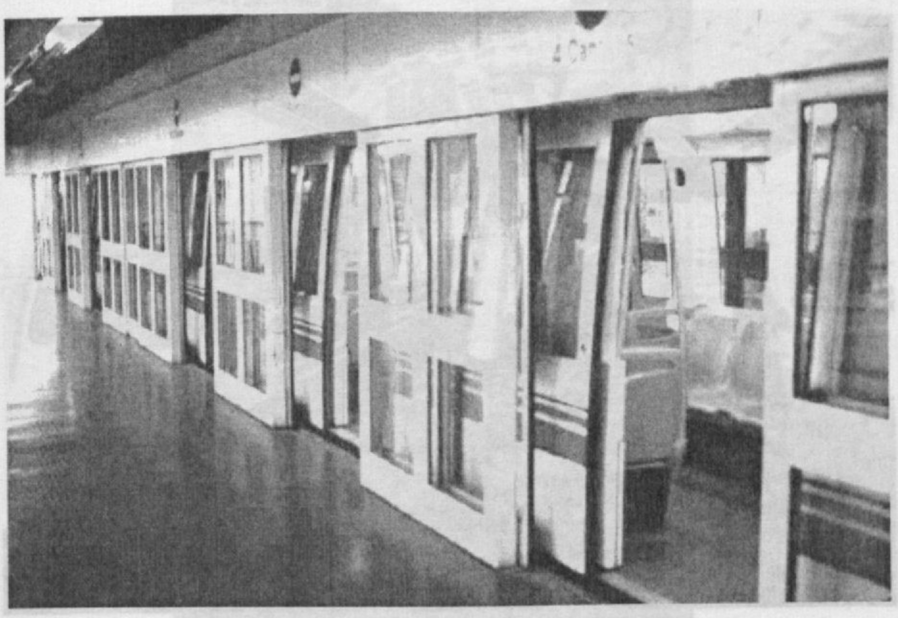

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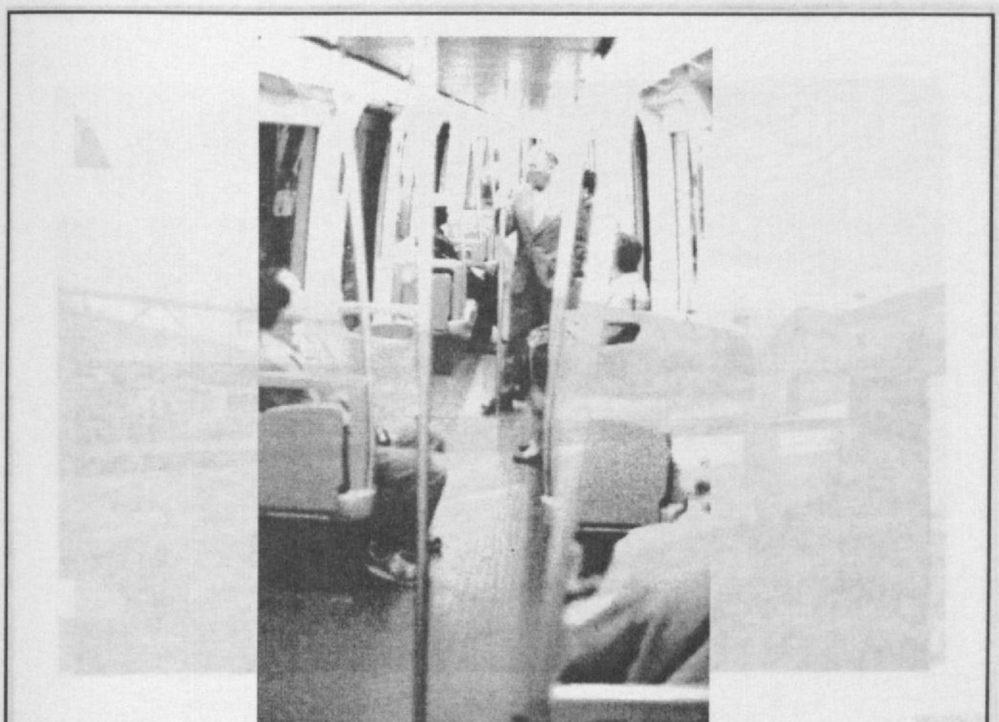

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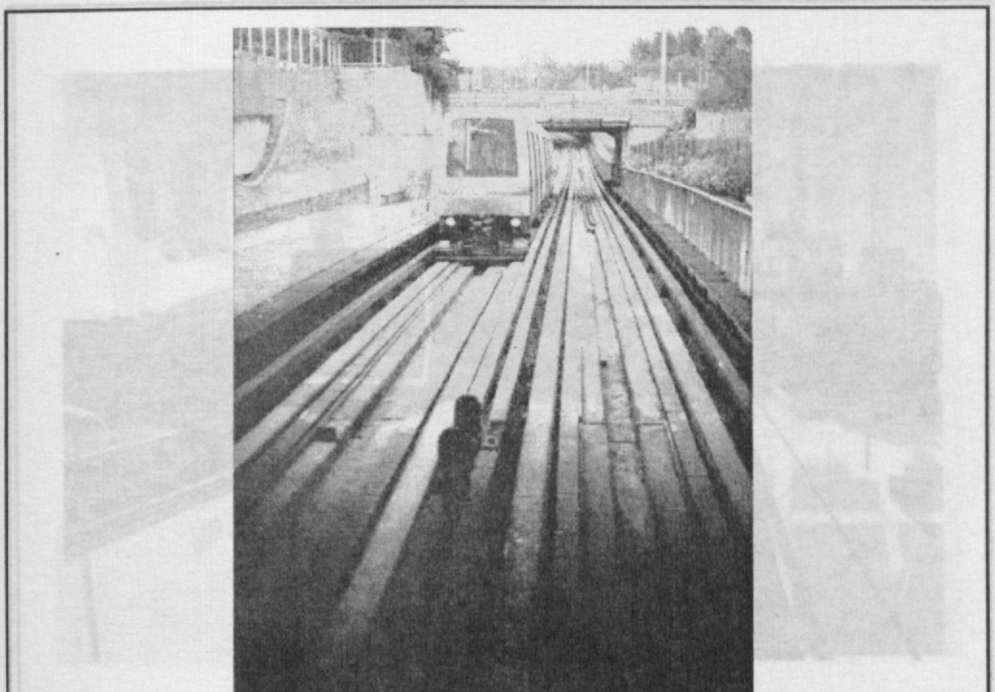

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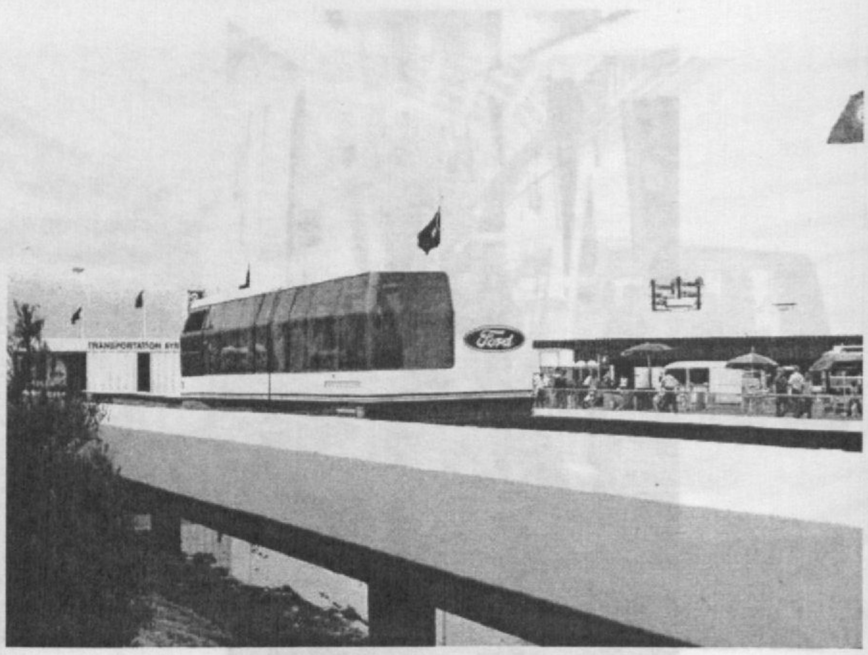

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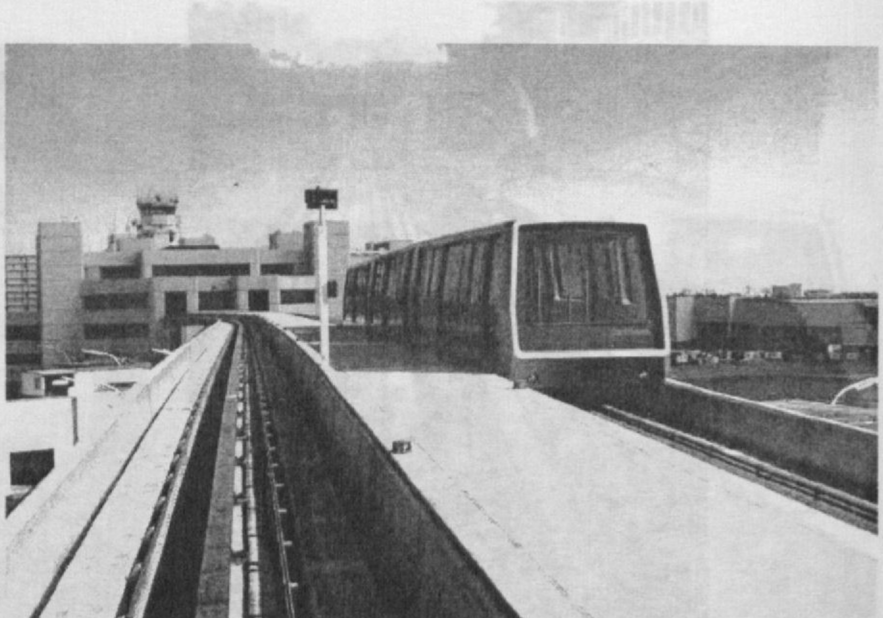

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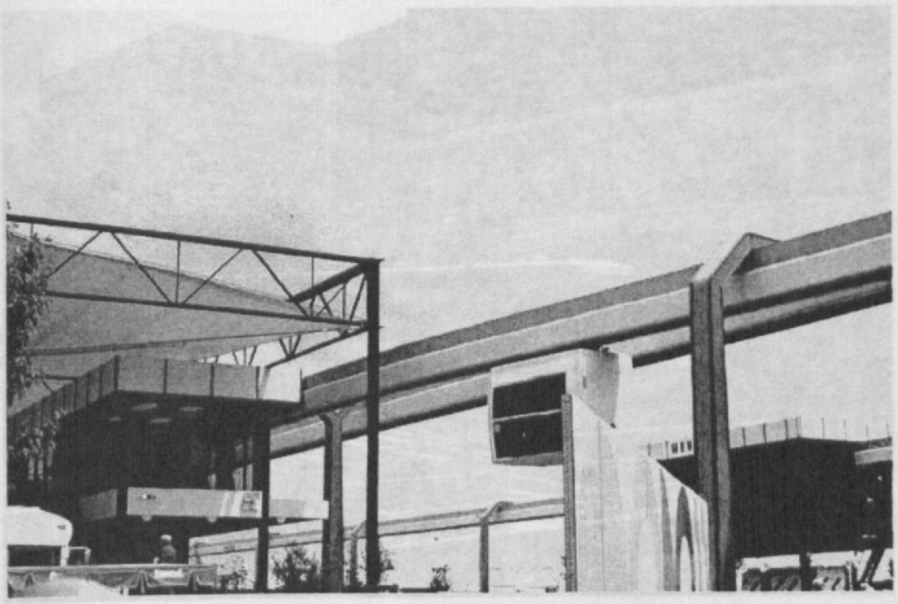

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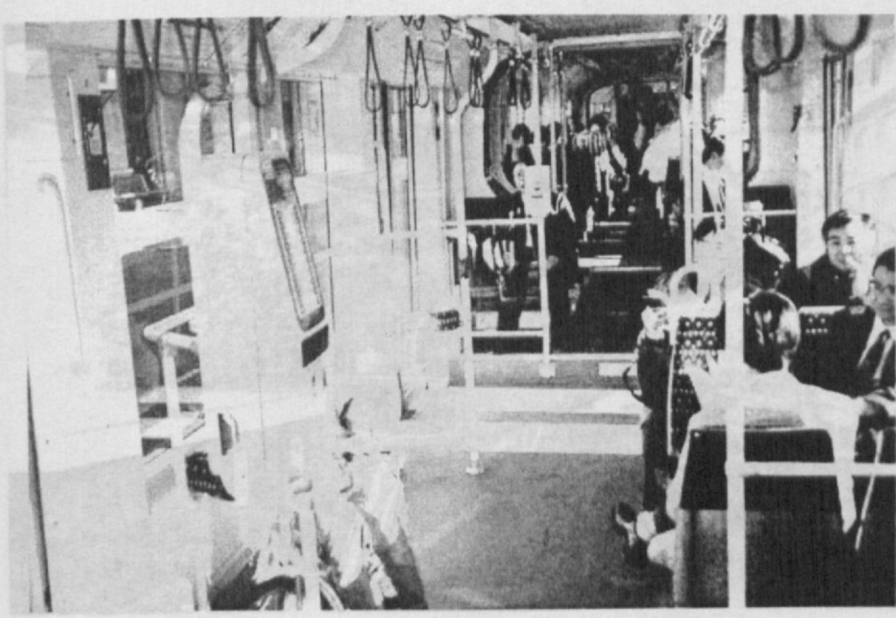

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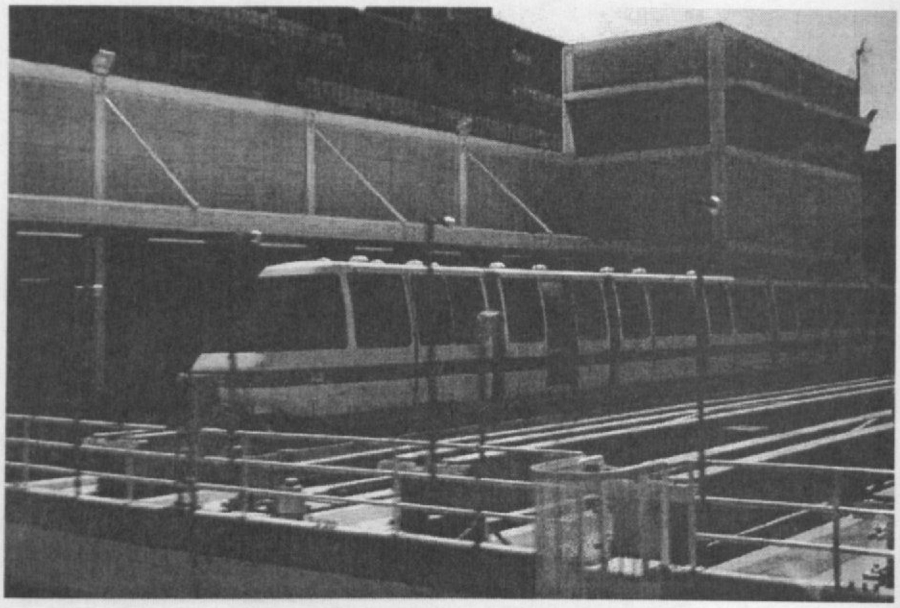

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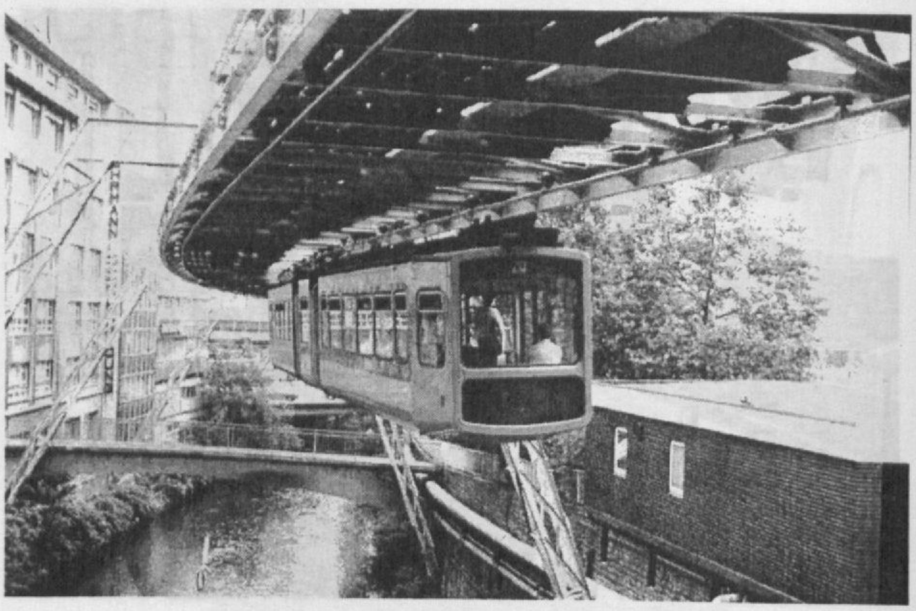

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