AUTOMATED GUIDED TRANSIT VERSUS CONVENTIONAL RAIL

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During the 1960s only two transit modes had a significant role in U.S. cities: buses and rail rapid transit. Although a number of cities needed transit systems with higher performance and capacity than buses could offer, they could not afford the high investment required by rapid transit. Subsequent developments of transit systems in this medium-capacity range occurred largely independently from two different directions: (a) Gradual improvements of rail technology and innovative concepts in their rights-of-way and operations led, over a period of time, to the emergence of modern light rail and rapid transit systems that had little resemblance to their predecessors of the 1950s *(1)*. (b) Private-sector research and government-funded demonstration projects produced new automated guided transit systems.

Although extensively discussed and promoted, until recently the automated guided transit systems found application only as local shuttles—for internal circulation in large airports, fairgrounds, campuses, and so forth. However, in recent years these systems were adopted for the first time for use by several regular transit lines. Kobe New Transit and Osaka New Tram in Japan *(2)*, initially operated with an attendant on each train, were designed for automated operation; and VAL system in France, Skybus in Miami, and UTDC's ALRT in Toronto, Detroit, and Vancouver are following the Japanese systems as regular transit lines.

The operating experience of the VAL system in France, which is necessarily fully grade-separated, demonstrates that automated transit can be efficient and reliable.

The prospects for implementing automated transit systems in cities and their relationships with various forms of rail systems were discussed at the 1985 TRB Annual Meeting last January in a panel discussion at the session on Rail Transit and New Technologies, which was jointly sponsored by the Committees on New Transportation Systems and Technology and on Rail Transit Systems. The panel

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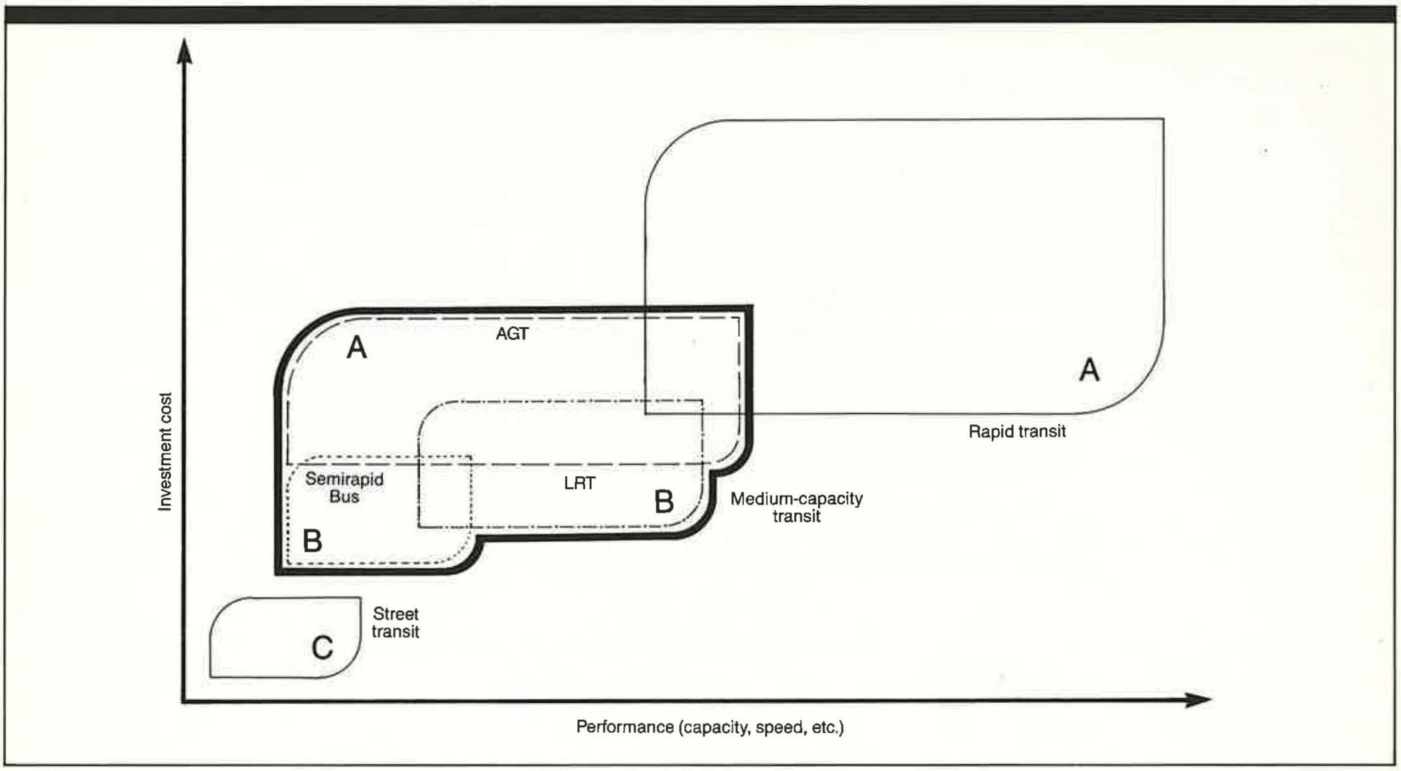

FIGURE 1 Both automated guideway transit and light rail serve the medium-capacity market *(3,6)*.

members were Daniel Brand, Charles River Associates; Scotty Davidson, Davidson and Associates; Thomas J. McGean, Lea Elliott McGean and Company; Paul Bay, Houston Metropolitan Transit Authority; and Manual Padron, transit consultant, Atlanta, Georgia. A summary of the discussions that took place at the session follows.

DEFINITIONS AND DIFFERENCES

Both automated guided transit (AGT) and light rail transit (LRT) are designed to serve the medium-capacity transit lines (Figure 1). In that sense they are modal competitors. But there are several fundamental differences in how they approach that market. McGean cited the definition of AGT from an Office of Technology Assessment study *(4)*: "a class of transportation systems in which unmanned vehicles are operated on fixed guideways along exclusive rights-of-way."

"If it's not driverless, it's not AGT," McGean stated during the panel discussion. The AGT guideway must consequently be exclusive; no intrusion onto the guideway can be allowed. The high capital cost to assure exclusivity is the principal disadvantage of the mode. The principal advantage is that automation allows short headways during all hours. With conventional rail, headways are often lengthened during off-peak hours to save labor costs.

The distinguishing feature of the light rail concept, according to a U.S. DOT report on light rail, is the ability of the system to operate safely and efficiently through at-grade conflict points. Other manned rail vehicles operate on reserved or exclusive rights-of-way. This periodic integration with mixed traffic compromises the quality of service of light rail—a disadvantage that is traded off by the lower capital cost of the LRT system. The ability of light rail to operate over a range of right-of-way types allows for incremental upgrading, which, as Bay emphasized during the panel discussion, is an important consideration in today's funding outlook.

AGT COMES OF AGE

The VAL system in Lille, France, dispels any notion that the AGT concept cannot operate in an urban transit environment. Davidson elaborated at the session: "The 8-mile (13-km) long VAL system has been in revenue operation since May 1983. Two-thirds of the line is in subway and the rest on aerial structure. Headways during peak periods are sometimes only 60 seconds; for the remainder of the 20-hour operating day, 5 minutes. Daily ridership last October was 95,000, higher than the most optimistic prebuilt forecast. The line cost $330 million (1982 equivalent) or $41 million per mile ($25 million per km). A total of 175 employees operate the system for a productivity rate of 8 employees per million annual passengers. The 40-cent fare recovered 84 percent of the total operation and maintenance costs. On-time performance and vehicle availability at about 99 percent equal or exceed the best rapid transit rates. Two additional lines are being

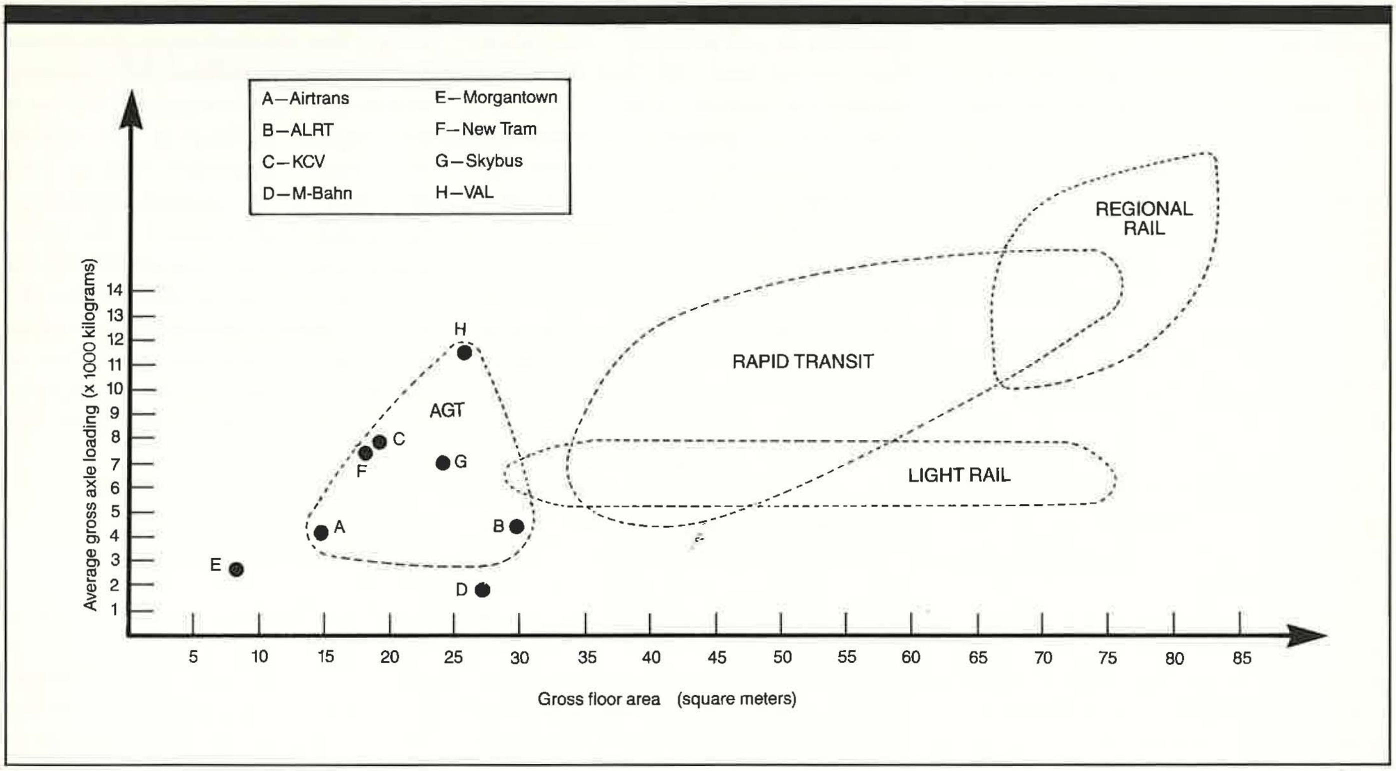

FIGURE 2 AGT systems often have axle loadings in excess of LRT axle loadings *(3,6)*.

engineered; one is contractually under way." [Further information is available on the VAL system *(3,5)*.]

Oversold or Undervalued?

Despite such a high level of performance, the transit industry remains skeptical of AGT. Has the AGT concept been oversold, as the skeptics believe, or has it been undervalued, as its proponents claim? Has time changed the answer? Panel moderator Brand remarked that with time, "on the one hand we become more sophisticated in our ability to implement advances in technology, but on the other hand some of our aspirations as to what new technology can do can come crashing down."

The AGT concept probably was oversold at first. Reliability was touted without any "real-world" experience, as were projections of capital and operation costs. Aerial guideways were shown far lighter than axle weights would warrant (Figure 2), and the environmental consequences and costs of such structures were underestimated. AGT systems were offered as safe, accessible, and air-conditioned, whereas conventional rail by implication, if not accusation, was unsafe, inaccessible, and stuffy. And finally, AGT concepts were said to be suitable to a wide range of applications—from airport shuttles to full rapid transit.

Because most of the AGT development occurred outside of the transit industry by private firms that offered their own proprietary technologies, the new systems often failed to respond to the needs of operating properties. For example:

- Demand-responsive service was emphasized and the higher capacity and reliability benefits of regular, fixed service were ignored.
- Small vehicles were favored even though most passengers would be standing. Such vehicles did not supply the capacity and comfort needed for regular transit lines.
- Very short headways (1 minute or less) were emphasized without a clear need for such service. (In fact, transit operators try to avoid operations with less than 90-second operation.
- Rubber-tire operation was used with disregard for operational drawbacks: switching may be more difficult, guideways cannot cross each other, vehicle size is limited, and energy consumption and heat production are higher.

These problems in development increased the already strong skepticism of transit operators regarding the AGT concept.

On the other hand, the transit industry has traditionally failed to recognize the advantages of fully automated operation:

- Ability to offer short-headway services throughout the day at no extra cost (short trains).
- Increased flexibility of operations: trains can be easily placed into or taken

out of service in response to unforeseen conditions.

- Futuristic image of automated service may attract additional ridership.

With the need to provide high-quality transit service, and with increasing financial pressures due to increasing labor costs, has the AGT concept become more attractive?

WHERE IS EACH SYSTEM BEST SUITED?

"The first thing you look for when you are trying to find a place to use AGT is 24-hour-a-day service," advised McGean. "The other thing that you want to look for is a very short waiting time requirement." Therefore airports and major activity centers are first choices for installation; trips from these locations are short and thus waiting times must be short.

By comparison light rail appears to be best suited for installation at locations where at-grade operation is possible with relatively few cross streets. Where an LRT line must cross major arterials, the need to accommodate cross traffic may prevent LRT headways below 5 minutes (an average of 2.5 minutes between trains in both directions). To achieve high capacity during peak hours, large transit units must be operated—trains with two to four cars, usually six- or eight-axle articulated types.

But what can be done when at-grade operation is not possible? And when there are no short trips and no strong demand for 24-hour service? One possibility, McGean speculated, is a marriage of the concepts of light rail and full automation; for example, UTDC's "Advanced LRT" under construction in Vancouver and Toronto *(3)*.

During the panel discussion, Padron also shed some light on this gray area by reporting on a series of studies done in Houston. Two corridors were studied: an 18.5-mile (30-km), high-volume corridor (15,000 peak-period, peak-direction passengers) and a 4.5-mile (7.2-km), medium-volume corridor (7,000 passengers per hour). Five technologies were compared: light rail, heavy rail, two AGT systems, and a monorail. In the high-volume corridor all systems that were fully grade separated had similar annual capital and operating costs. If light rail is operated partially at grade (the only mode with that capability), it becomes 10 percent more cost-effective than the others (number of passengers held constant). In the shorter corridor, one of the AGT systems was 10 percent less cost-effective than the other modes. In this corridor, light rail could not have operated at grade.

Bay and Padron offered another perspective that may assist transit planners. "It may not be a really smart idea to develop a plan for a massive 150-mile transit system in one technology all at once," Bay said. "When we do that it then obviously becomes difficult to take advantage of technological changes over time." Two alternatives are time-phased development or incremental upgrading, which allow for incremental change in the original building of the system. "And that is important—you can take advantage of incremental upgrading," Bay added. Padron agreed: "We can no longer deploy an expensive guideway system all at once in this country. It's going to happen incrementally, and the most cost-effective rail system for all corridors over time in the development of a regional system would be light rail."

CONCLUSIONS

The TRB discussion at the session on Rail Transit and New Technologies held during the 1985 TRB Annual Meeting and current developments in and deployment of guided transit systems lead to the following concluding observations.

- *Light rail transit* has a unique feature: it is the only guided mode that does not require a fully separated right-of-way (category A). Its ability to utilize any right-of-way (A, B, or C) allows substantial investment savings, but also causes performance limitations and prevents full automation. This mode has the greatest diversity of applications and is adaptable to gradual upgrading of rights-of-way and operations. Unlike some AGT systems, LRT has no proprietary limitations; it is based on rails,

Rail Transit and New Technologies was the subject of one session at the 1985 TRB Annual Meeting in Washington, D.C., last January. In addition to the presented papers, the session, presided over by Richard M. Stanger, included a panel discussion on "New System Technologies Versus Conventional Rail: Has Time Changed the Balance?"

TABLE 1 Basic Characteristics of Guided Transit Modes

	Support/Guidance		Driving		Offered Capacity
Mode/System	Rail	R. Tire	Manual	Automatic	Veh. Cap. x Cars/Train x Max Freq.
LRT	x		x		170 · 3 · 45 = 22,950
Omiya, Japan		x	x		62 · 6 · 40 = 14,880
New Tram, Osaka, Japan		x		x	62 · 4 · 30 = 7,440
KCV, Kobe, Japan		x		x	62 · 6 · 30 = 11,160
VAL, Lille, France		x		x	86 · 4 · 48 = 16,512
Skybus, Miami, Florida		x		x	70 · 6 · 40 = 16,800
ALRT, Vancouver	x			x	100 · 6 · 48 = 28,800
Rubber-tired rapid transit		x	x		120 · 9 · 40 = 43,200
Rail rapid transit	x		x		180 · 8 · 40 = 57,600
Automatic rapid transit	x			x	180 · 8 · 40 = 57,600

the most conventional guided technology.

• *Automated guided transit* has matured both in technology and concepts. A number of AGT technologies have proven operating records. The exotic operating concepts, such as small vehicles, on-call operation, and off-line stations, have been gradually replaced by concepts with standard transit characteristics: transit units (trains) have capacities of 150 to 450 spaces and operate on fixed headways with minimum values of 1.0 to 2.5 minutes. Moreover, physical characteristics, such as alignment geometry (radii, gradients, cross-sectional profiles) and axle loadings, are similar to those of rail systems. The uniqueness of the AGT mode is its full automation, which requires category A right-of-way only, causing large investment requirements, but providing significant operating advantages of short headways at all times and flexibility of operations. AGT systems have proven that fully automated systems are not only acceptable to the public, but are quite attractive to it.

AGT now dominates short shuttle services within major activity centers; but AGT applications for regular transit lines are still limited and prospects for this role depend on lowering the cost of these systems compared with that of conventional rapid transit. In other words, AGT is a "more luxurious" and "more expensive neighbor" of LRT; whether it can be a "mini-rapid transit" with correspondingly lower costs remains to be seen.

• *Rail (and rubber-tired) rapid transit* continues to be the superior mode in the high-capacity domain; for capacities over 25,000 persons per hour it is the only feasible mode. With some modifications, rapid transit can also be fully automated.

Technological and system developments during the last 25 years have created a greater variety of transit systems. The systems discussed here can be ordered into a virtually continuous "family of guided transit modes," from LRT (which requires the lowest investment) to various AGT systems to rapid transit (which requires the highest investment). As the panelists pointed out at the TRB session, the "transitional modes," such as ALRT (with conventional or linear electric motors), often combine the good features of the two major groups: rail technology and full automation.

For review, the major rail and rubber-tired conventional and new systems are listed in Table 1 along with their basic characteristics: support/guidance technology, driving method, and capacity. The unit investment costs (per kilometer) generally increase from the first to the last system, as listed in the table.

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