Automated Transit Dissected: An Overview of Lawrence J. Fabian's Writings

Abstract

Lawrence J. Fabian (1945-2020) shared his expertise in automated public transportation, during a 40-year career, through his voluminous writings. He defined automated transit as large, driverless vehicles operating on guideways, with the primary potential benefit of high-frequency service. One of his products was an annual, worldwide list of automated people movers (APMs). The first, from the early 1980s, featured 20 operating lines. By the 2000s, there were over 100 – today, there are over 200. He introduced three APM classifications: architectural, institutional, and mass transit. Architectural APMs operate within a single entity, such as an amusement park or airport. Institutional APMs serve large developments, such as a resort center or district. Mass transit APMs operate in an urban context. While his early APM lists were 50% architectural, 25% institutional, and 25% mass transit, there was a shift toward mass transit applications, particularly in Europe and Asia. But, urban APM applications in the U.S. stalled after federal involvement during the 1970s and 1980s. Fabian bemoaned the U.S. stagnation, while praising innovation and progress worldwide, noting the now-numerous driverless metros. He suggested that private sector involvement might bring about more urban APMs in the U.S. A case study of the Las Vegas Monorail indicates, though, that it is difficult to keep a transit system afloat in the U.S. without government subsistence. Another federal boost for driverless transit, now over 40 years since the Downtown People Mover Program, may be needed to bring U.S. urban APM use on par with that overseas. Minus this, the APM industry is nevertheless strong worldwide.

Keywords

Automated transit, automated people movers, public transportation, personal rapid transit, driverless metros, airport automated people movers, airfronts, Downtown People Mover Program, small-scale transit

Introduction

This paper reviews and summarizes the published writings of Lawrence J. Fabian (1945-2020), who passed away on February 21st, 2020 after a bout with Hepatitis A, picked up while traveling in the Dominican Republic. Fabian's career thrust was toward automated forms of public transportation, especially automated people movers (APMs) and personal rapid transit (PRT). He wrote voluminously, far too extensive to discuss in full here. His mission, in his writings, was to report information and developments, as opposed to any data analysis or technological design. The bulk of his writings are in newsletters and other postings. Yet, he published extensively; this paper focuses on those in which he is the lead author. He has a total of 43 lead-author works in the literature, based on compilations provided by Google Scholar, ResearchGate, Semantic Scholar, Transportation Research Information Services (TRIS), and WorldCat. Note that no single site offers a comprehensive listing of Fabian's publications. While Fabian emphasized, perhaps, the "soft" side of automated transit systems (i.e., planning and operations), his expertise was sufficient enough for the mechanics and propulsive dynamics of the technologies about which he wrote. Being no shrinking violet, his criticisms of poorly-developed technological proposals once found him on the losing end of a million-dollar lawsuit by a PRT company (Sikora, 1990). One can surmise that Fabian's writings are deep and thoughtful enough to demand attention.

Overview of the Fabian Literature

Abstracts and-or full content of 37 of Fabian's 43 publications were obtained for this paper. The 37 reviewed works span multiple formats, including eight articles in conference proceedings, 18 articles in trade journals, nine articles in academic journals, one book, and one compendium of market information. Excluded are numerous newsletters, spreadsheets, discussions, and quotations that Fabian either produced or authorized. Of the six missing publications, two were in limited availability, and two are in trade journals for which archived issues were not available. Two others possess titles but unidentified sources. Thus, this paper considers 86% of Fabian's published works. The following 14 topics, themes, and points of discussions were identified:

- Airports and "airfront" circulation
- APM station design
- Applications, classifications, contexts, and scales of APM operation
- Benefits of automation
- Commonalities between elevators and automated transit
- European vs. American rail transit
- Federal support for APMs; critique of the Downtown People Mover Program
- Lack of and need for automated transit data
- Lists and highlights of automated transit systems worldwide
- Overview of the APM industry
- Private APM operation vs. conventional transit agencies
- PRT: description, history, prototypes
- Sizes and costs of APM systems; comparison with conventional rail
- Small-scale transit: costs and usefulness

Fabian also wrote one, isolated piece, on Singapore's congestion pricing scheme (Fabian, 2003). He had a knack for introducing terms to the transportation lexicon, although he was not necessarily the originator. These include "Airfront," in reference to an airport's external influence area, and "Smart Transit," as used in a 1985 paper (Fabian, 1985), predating computer-based "smart" applications. He may have been the first to formally use "horizontal elevator" in the literature (Fabian, 1993a), as well as "E-Cab," in reference to a driverless taxi (Fabian, 2006a); since then, the definition of E-Cab has changed to an electric cab that has a driver. He was also known for generating catchy, nearly whimsical titles, to attract readers, as a mask for serious and introspective content.

Personal Rapid Transit

The preceding 14 bullet items are dominated by topics and themes related to APMs. Fabian clarified the distinction between APMs and PRT early on, with the former featuring large, driverless, guideway vehicles that visit every station along a route. He describes PRT as "small light vehicles carrying up to six passengers and operating over a network of exclusive track without multiple stops" (Fabian, 1992a). In (Fabian, 1992b), he further clarifies "without multiple stops" as "no intermediary stops." While Fabian was a champion and proponent of PRT, it was not in the forefront of his writings. Yet, his earliest work was a book on PRT, – (Fabian, 1979). While PRT was conceived in the early 1950s, he argues that the modern-day PRT concept did not emerge until the 1970s. There was a PRT "fever" during that decade that quickly faded, but was later revived as computerized control systems gained sophistication. By the early 1990s, with new technology invading transit system architecture, there were eleven PRT prototypes under development (Fabian, 1992a). He also notes the potential for PRT applications in airport and airfront settings (Fabian, 1990). In (Fabian, 2006a), he describes the Morgantown, West Virginia PRT system, which was the only operational PRT to emanate from the 1970s "fever." The system was inaugurated in 1975, and was just over 30 years old at the time of publication. The system was plagued by a three-year construction delay and an up to fourfold construction cost overrun, but had endured well, despite the dated 1970s, and then early 1990s computer control technology. He takes advantage of the Morgantown success to highlight the advantages of PRT, including the inherent flexibility in station spacing and locations.

<insert Figure 1>

Airports and Airfronts

One of Fabian's "pet" subjects was the airfront – the airport's landside. He reported that landside, near-airport development, and the associated circulation, had transformed many airfronts into environmental hot spots. These were generating more pollutants than the airside activities. To reduce mobile and idling emissions, one solution would be automated transit (Fabian, 1979; Fabian, 1990). He notes that airport APMs (AAPMs) had grown into a competitive industry since the inaugural system was established at Houston's Intercontinental Airport in 1969. The need for that AAPM, and subsequent systems at Chicago, Dallas, Paris, and at least ten other airports (as of 1990), had been generated by phenomenal growth in air travel since the late 1950s. Consequent to increased activities on the airside were developments on the landside, in land uses ranging from tourism (hotels, car rental facilties) to industry (manufacturing, warehousing) to business (offices, exposition centers). Some of these mini-cities grew to include residential development, as in Rosemont, Illinois, near O'Hare Airport. By the mid-1990s, over 40 AAPMs were under construction or in the planning stages worldwide (Fabian, 1979; Fabian, 1990). All of these are now in operation.

<insert Figure 2>

Outside of the fence, as Fabian phrases it, the potential for AAPM extensions to the airfront seems logical. But, in most cases lacking a master plan, airfront development has been subject to sprawl, inefficiency, and low densities. Such development patterns are notorious for generating disparate roadway congestion, and being hard to serve by traditional public transit. Even the ability for AAPMs to serve this environment is limited to concentrated or "rationalized" development, as he describes. Several coordinated planning efforts were underway as of the early 1990s, including ones in Chicago, Newark, and Seattle. If the complex layout of the airfront cannot be effectively served by an AAPM, then one approach would be to connect a nearby rail transit station with the airport, as in San Francisco (Fabian, 1993b). (San Francisco's AirTrain was in the final stages of planning as of Fabian's writing; construction was completed in early 2003). He also saw consolidated car rental facilities (CRFs) as a further opportunity for AAPM applications (Fabian, 2001a). He concedes that standard shuttle bus systems were serving CRFs effectively, but that these could be "upgraded" with APMs. The upgrade would be in freeing up roadways. The primary drawback would be the infrastructure costs, dependent on the length of guideway needed, and the passenger demand. He suggests that daily ridership under 10,000, and-or an airport-to-CRF distance greater than 1.5 to 3.5 km (1 to 2 mi) would represent do-not-build criteria. To boost the opportunities for building an off-airport AAPM, he suggests combining CRFs with long-term parking and regional transit centers. Such integration had already occurred, or was in the construction phase, at airfronts in Minneapolis, Newark, and San Francisco.

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APM Stations and Structures

A subspecialty within Fabian's discussions of APMs is stations. He emphasizes the criticality of stations in APMs, and rail transit in general, noting the impacts of their number, location, and configuration. The small scale of APMs, relative to traditional rail transit, enables station placement within buildings. The design choices in building contexts pit platform walls versus open platforms, platform doors versus open access, transit station layout protocols versus building codes, and transit management versus building management (Fabian, 2001b; Fabian, 1997a). He also notes how fire protection issues can be much stricter within a building than in a separated station (Fabian & Griebenow, 2001). Overhead guideway underbellies, columns, and footings all become part of the surrounding fabric, once built. He suggests that there are opportunities for collaboration between architects, engineers, and planners (Fabian, 1993c).

APM Operations

One of Fabian's favorite APM topics was operations, including their applications, classifications, contexts, and scales. In a 1983 paper, he notes that urban applications of APMs marked a major turning point from their previous uses in purely recreational settings (Fabian, 1983). He also notes the differing operational and economical attributes, in comparing APMs with conventional mass transit. There was a Downtown People Mover Program (DPMP) in the U.S. at the time, with federal government support. He points out how an APM could best work in a downtown, recommending train consists with capacity for 75 to 100 passengers. It would be another 14 years before Fabian would specifically revisit APM operations and settings (Fabian, 1997b). By then, the DPMP years had passed, and the U.S. had several urban APMs; plus, there were multiple systems worldwide, using a variety of extant technologies. In his next effort on the topic, he clarified the various scales of APM operation, with three classifications: architectural, institutional, and mass transit (Fabian, 2000a), explained as follows. The proportions of those as of 1998 were:

- Architectural – airport, amusement, leisure, and recreational settings (51% of all APM systems)
- Institutional – hospitals, shopping centers, universities, and urban districts (23%)
- Mass Transit – downtowns and other public, urban settings (26%)

An architectural APM operates within a single architectural complex. In (Fabian, 2001c), he indicates that these have a capacity of about 1,000 persons per hour. In the broadest sense, he notes that elevators, escalators, and moving walkways could all qualify as architectural APMs. But, he adheres to a stricter definition in which the APM involves vehicles operating on guideways. Otherwise, the list would be quite long! Institutional APMs are characterized as serving multiple properties, perhaps within a large, multi-building complex, and being open to the general public. System operations are private, rather than being tied to a transit agency – perhaps with some coordination. Institutional APMs are in the domain of public-private partnerships, as he describes, which can be effective. Mass transit APMs represent the most expansive technological category, particularly in terms of consists, which can range from a single vehicle to a 10-car train. The only requirement is that the consist be driverless. Hence, any driverless metro providing line-haul service qualifies as an APM. As of 1998, the diversion between urban automated transit experiences in the U.S. versus those in Europe, and east Asia, was pronounced. In the U.S., only urban APMs that were produced during the federal-involvement years of the 1970s and 1980s were in operation. In contrast, there were 16 driverless metros and urban APMs in operation worldwide, with several more in the pipeline.

As of this writing, over 20 years since Fabian's survey, the U.S. has a healthy number of architectural APMs, particularly at airports. Yet, there has been little development of mass transit APMs in the U.S. Only two APM lines in Las Vegas – the Aria Express and the Las Vegas Monorail, completed since the Fabian writings – could be loosely-defined as "mass transit," given that they are oriented toward Las Vegas Strip tourism. In (Fabian, 2001d), he notes that mass transit APMs, unlike APMs at the other two scales, can be mired in a political process. The latter involves metropolitan planning organizations, local governments, transit agencies, and other players. He notes that the dynamics of the multiple involvements are substantial in the U.S., with complex decision-making.

Benefits of Automation

In a few articles, Fabian responds to the fundamental question "why automate?" in discussing the benefits of automated transit. An International Public Transit Association (UITP) Working Group formed in 1986, shortly after the opening of Vancouver's SkyTrain Expo Line. The Group identified the following benefits (Fabian, 1989; Fabian, 1996):

1. Excellent performance, superior to that of manual operations
2. Greater vehicle-km to labor-hours ratio
3. Happier crews (reduced monotony; shifting of routine jobs to computers)
4. Increased system security
5. Investment + maintenance costs < costs of operations with drivers
6. More effective deployment of staff
7. Opportunity for high-frequency short trains
8. Potential for real-time operational adjustments
9. Reduced operational staff

One of the most critical benefits may be the seventh. The high cost of labor warrants the efficient use of an operator, and long trains. Removing the driver enables more frequent service, such that consists of one to three cars could offer the same capacity as a line-haul service. High frequency service is generally perceived by transit users as superior to that with lower frequencies. The third and sixth benefits are also critical, deflecting the perceived detrimental effect on transit labor. Workers remain, but are shifted to new duties such as controls and security. Despite the clear benefits, Fabian admits that the main disbenefit of APM implementation is the high capital costs (Fabian, 2000a).

Elevators and APMs

Fabian identified a connection between elevators and APMs, noting the technological similarities, and common operational objectives. For example, there are several cable-drawn APMs worldwide that operate the DCC Doppelmayr Cable Car; the technology is similar to that used in cable-drawn elevators. Also, as an elevator is confined to a vertical shaft, many APM systems are simply back-and-forth shuttles. On-demand service and prioritized stopping in elevators preceded the implementation of those capabilities in APMs (which are not widespread). Despite the commonalities, and his nine publications in *Elevator World*, he noted that no one from the elevator industry was in attendance at a 2005 international APM conference (Fabian, 2005). Perhaps one reason is that elevator operations had been more progressive than in public transit. “Driverless” elevators gained popularity as early as the 1950s (Fabian, 2006b). Today, elevator operators are nearly extinct, although they still exist, such as in over 50 buildings in New York City (plus several subway stations), several other U.S. cities, and in Japan and Taiwan (Newman, 2017). Given the countless number of automated elevators, though – there are millions worldwide – the willingness to progress in that industry is evident (Bernard, 2014). He discusses the potential for further technological synergy in (Fabian, 2000b), where linear induction motors (LIMs) are suggested for use in both horizontal and vertical transport. At the time, LIMs had been in use in several APM systems for nearly 20 years. Today, LIMs are being considered for deep vertical shaft elevators, but not in “everyday” elevators; they were also being used in sliding doors. While not going so far as to suggest that the elevator industry should be a model for the automated transit industry, Fabian reiterates the linkage (Fabian, 2007a).

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European vs. American Experiences in APMs

Fabian emphasized the growing diversion between Europe and the U.S. in applications of APMs. He first observed the disparity in 1981, when about 20 APMs were in operation worldwide. With respect to urban APMs, in the U.S., the Morgantown system was running, and others were being planned as part of the DPMP. Two were operating in Japan, and the construction of another was nearing completion in France (Fabian, 1981a). By the end of the 1980s, there was progress with APMs in Europe (Fabian, 1989), and the UITP’s findings on automation had been disseminated. Consequently, A~~T~~PM projects, including driverless metros, were in five European countries. The greatest levels of activity were in France, which had established a national institute on automated transit (CRESTA) in 1983 (Fabian, 1998). Fast forward two decades, and Fabian laments the lack of progress in the U.S., versus that in Europe and east Asia. He notes that driverless metros were practically “routine” in Europe (Fabian, 2001d). In the “French” paper (Fabian, 1998), he reports that transit ridership per capita in Paris was twice that in New York City, which is the U.S.’ top transit city. The transit habit in France had been established as early as the 1920s, and had been nurtured by ongoing transit investments and improvements. The suggestion is that the slothful development of urban APMs in the U.S. is a byproduct of a progression that has not fostered a strong transit habit (a discussion that is too lengthy for this paper). Regarding Europe’s growing cache of driverless metros, Fabian notes that the U.S. had produced some fine metros, including those in Atlanta, San Francisco, Washington, and elsewhere. Yet, the higher frequencies, greater reliabilities, cost efficiencies, and aesthetic amenities and comforts of the European metros were enviable (Fabian, 2007b).

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Federal Investment in APMs

Closely tied to the discussion of European success with APMs, versus slow to non-growth in the U.S., is the history of federal investment in APMs. Fabian discusses the latter in two early 1980s papers (Fabian, 1981a, Fabian, 1981b). At the time of those writings, federal involvement in APMs was at its peak, with the DPMP poised to produce several downtown APMs. Now, 40 years later, the U.S. has not returned to that level of investment in or attention to APMs. Fabian's writings do not revisit the DPMP; the general consensus was that the DPMP was not a success. A major factor may have been the speed with which the program and overall interest in advanced transit systems moved. The Urban Mass Transit Administration (UMTA) was established in 1966. Research and development in novel transit systems commenced immediately. As a reaction to a lack of interest in the innovative technologies demonstrated at TRANSPO '72, the DPMP was created. By 1976, 68 cities had submitted either letters of interest or proposals for downtown APMs. In the meantime, the federally-funded Morgantown PRT system was put in operation, albeit delayed, with cost overruns. As many as eleven cities were approved for full or partial DPMP funding. Interest quickly waned among the cities, with only two, Detroit and Miami, persevering long enough to build APMs. Later, Jacksonville – one of the original eleven cities – also built an APM. But, a 1980 General Accounting Office report criticized the DPMP, and the $675 million program cost. Added to the apparent boondoggle were conflicting commitments by UMTA, U.S. Senate committees, and the cities themselves on which systems were most critical to meeting DPMP objectives (Merritt, 1993). Fabian mostly avoided DPMP negativity, preferring to maintain a positive perspective on APMs, and the many overseas successes.

<insert Figure 7>

List of Automated Transit Systems Worldwide

One of Fabian's most enduring endeavors was his annual worldwide list of APMs. Being too long for publication in an article, his preferred format was a spreadsheet, circulated to Trans.21 subscribers. The increased usage of train automation led, in 2006, to the establishment of standards by the International Electrotechnical Commission (IEC). The IEC publication has since been withdrawn, but the automation categories have been adopted by the UITP (UITP, 2021). The automation grades range from GoA0 ("grade of automation zero"), which is completely manual, to GoA4, which is completely automated (i.e., no driver or attendant, with automatic train protection). Fabian generally considered only GoA3 and GoA4 systems to be APMs. (GoA3 employs an attendant for door closures and in the event of a disruption, but is otherwise automated). Table 1 provides a summary according to Fabian's definitions of APM scales, as discussed earlier. Airport APMs, which are architectural, are listed separately, as are shuttles (i.e., back-and-forth, with endpoint stops). Five countries are listed individually, because they are world leaders in their numbers of APMs: China, France, Japan, South Korea, and the U.S. The U.S. has more GoA4 and GoA3 APMs than any other nation, with 24% of the world's total, although the number in mass transit service is low. GoA2 APMs are not listed, but China would vault into the world lead if these were included. (GoA2 is similar to GoA3, except that a driver is responsible for door closures and disruption operations, rather than a train attendant). Outside of the five countries, APMs are summarized by continent. In Africa and Oceania, APMs are found in Australia and South Africa (Algeria has a GoA2 metro). In the Americas, APMs are found in Brazil, Canada, Chile, Mexico, and Venezuela. Fourteen Asian countries other than China, Japan, and South Korea feature APMs in mass transit service, particularly in Saudi Arabia and Singapore. Ten European countries, other than France, also feature APMs in mass transit service, as well as in airports.

There are 208 GoA4 and 19 GoA3 APMs as of this writing. The total reflects a tenfold increase in APM applications since Fabian's inaugural tabulations. A few were under construction, scheduled to begin operations in 2022. There have been some remarkable shifts since Fabian's summary paper (Fabian, 2000a). Architectural APMs, which include those serving airports, are now at 31% of all APMs, down from 51%. In contrast, mass transit APMs are now at 52%, up from 26% in 1998. Asia and Europe dominate the mass transit APM applications, with 47% and 42%, respectively, of the world's total. Note that mass transit lines are counted separately, as opposed to entire systems (some systems have mixtures of GoA lines). The categories can, in some cases, be difficult to define. For example, the Las Vegas Monorail is open to the public, but its service is limited to the Las Vegas Strip.

Some APMs have changed categories over the years; for example, the Dortmund H-Bahn in Germany originally served the University of Dortmund exclusively, but now also serves the Eichlinghofen district and a nearby technology park. Several APMs are no longer functioning, such as those formerly at Duke University, Indiana University, and Harbour Island in Tampa. Some architectural APMs may be missing from the compilation. These, usually short and confined to a single entity, can easily be overlooked. Funiculars or inclines are generally overlooked in APM compilations. For example, Angels Flight, a funicular in downtown Los Angeles, is excluded. While Fabian considers cable-driven APMs, his discussions exclude ropeways which, according to broad definitions, could be treated as automated transit. Ropeways include gondolas, lifts, and tramways. Table 1 also excludes the so-called "slope cars," which are exclusive to Japan and South Korea. These small, automated monorail vehicles are active at nearly 100 installations in the two countries. The route lengths are typically short (0.85 km or less), with a climb and descent gradient of 10% or more. The first opened at Soeda Park in Fukuoka in 1991 (Wikipedia, 2021a). If the slope cars are included, then Japan would be the world's APM leader, overtaking the U.S., and even China with its GoA2 systems.

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Overview of the APM Industry

While he was trained as a planner, Fabian was keenly aware of the business side of APMs. In a *Jane's Special Report* (Fabian, 1999), he provides a worldwide list of APM suppliers and consultants, and a ten-year market forecast according to his three APM scales. The report was published in 1999, and has not been updated. Previously, he published an article on the APM industry (Fabian, 1997c). The data in these late 1990s works were regularly updated, later, in his Trans.21 efforts. A collaborative 2014 report, published by the Mineta Transportation Institute and funded by the California Department of Transportation, features APM industry data compiled by Fabian (Furman et al., 2014). (The purpose of the report was to review the market potential for automated transit networks, including APMs, PRT, and other technologies). The APM industry was declared healthy, with multiple, competing suppliers, several of which had been active since the early days of automated transit development. As of this writing, Bombardier, based in Canada, is the world leader, with 38 active APM lines or systems worldwide. There are 29 SelTrac APM lines or systems worldwide; other top APM suppliers include Alstom (France; 17 lines or systems), Siemens (France/ Germany; 14), VAL (France; 13); Doppelmayr (Austria; 10), and Ansaldo Breda (Italy; 8). Kaho, based in Japan, has installed numerous "slope car" lines (number unknown). There are no major American APM suppliers, but Walt Disney Imagineering has developed APMs at Walt Disney World and George Bush Intercontinental Airport (Houston). Fabian noted that a few suppliers discontinued their involvement in APMs post-DPMP. These included major players having thrusts in other industries, such as Bendix (brakes and electronics; now defunct), Ford (automobiles), and Otis (elevators).

Table 1. Summary of Automated People Movers Worldwide as of 2021

Country or Continent	Airport	Architectural	Institutional	Mass Transit	Shuttle
China	2	2	1	14	0
France	1	0	1	12	1
Japan	1	0	2	7	0
South Korea	1	1	1	11	3
United States	20	16	11	3	4
Africa & Oceania	0	1	2	1	0
Americas	2	1	0	12	0
Asia	6	2	5	37	2
Europe	11	3	2	21	4
WORLD	44	26	25	118	14

(Fabian, 2000a; Fabian, various years; Wikipedia, 2021b; Wikipedia, 2021c)

Fabian estimated that APM project costs in 2013, excluding operations and maintenance, totaled $20 billion, with 92% invested in mass transit (Furman et al., 2014). Just nine years earlier, mass transit represented 62% of the investment, with a greater proportion to architectural and institutional systems. The investment levels in the latter two remained stable (institutional) or decreased (architectural) in the ensuing years, suggesting a major shift in the focus of APM development. To provide context, $27.5 million was spent on non-traditional rail transit in the U.S. in 2013, reflecting just 0.15% of the world's total (Neff & Dickens, 2015). Fabian's concern was the failure of the U.S. to adapt to the trend, as discussed above, and as is evident in Table 1. He also noted, in various writings (e.g., Furman, et al., 2014), the general unavailability of good cost and operational data.

Private Sector Involvement

Fabian recognized the potential for private sector involvement in APMs, with attention directed at urban service. (Architectural and most institutional APMs are in the domain of the private sector). He notes the attractiveness of small-scale APMs and the reduced operational demands, in comparison with conventional public transit (Fabian, 1990). He contends that large, private developments are plentiful in the U.S., and that some are built with an investment that exceeds that needed to build and operate a small-scale metro (urban rail transit) system (Fabian, 2007a). Thus, the scale of a small transit system is within the means of private development. In an earlier paper (Fabian, 2001d), he suggests that the ideal scale for private involvement, via a public-private partnership, is at the institutional level, equivalent to urban service in certain settings. Today, there are six institutional APMs which could be classified as urban: Skyrail Town Midorizaka (Japan), Las Colinas (Irving, Texas), the Las Vegas Strip (Las Vegas Monorail), Morgantown, Docklands (London, England), and Masdar (United Arab Emirates). The Morgantown and Masdar systems are best classified as PRT.

<insert Figure 11>

To focus on one system, the Las Vegas Monorail is a suitable case study for Fabian's private sector involvement theories. The Monorail opened in 1995 as a joint venture between two Las Vegas resorts: MGM Grand and Bally's. A shuttle connected the two hotels, using two Mark IV trains from Walt Disney World. In 2002, spearheaded by McCarran International Airport director Robert N. Broadbent, the Monorail was extended. Broadbent died just months before the 2003 reopening; it has since been renamed in his honor. The line was extended northward and southward adjacent Las Vegas' Strip, and the trains were upgraded to Bombardier Mark VI four-vehicle consists. Structural and operational integrity problems plagued the Monorail for over a year, though, forcing closures. It finally reopened, firmly, in December 2004. The new Monorail was owned and operated by Transit Systems Management (TSM); a private company. TSM had a short life, though, because of revenue losses during the 2003 and 2004 closures. In 2005, the Las Vegas Monorail Company (LVMC) assumed ownership; head operator Curtis Myles was the former deputy general manager of the Regional Transit Commission of Southern Nevada (RTCSN). How about that for a public-private partnership? Construction costs were covered by private monies, and bonds from the State. The latter totaled $600 million (total cost: $650 million). The system is now 6.3-km in length, with seven stations (Associated Press, 2004; Las Vegas Monorail, 2021; Wikipedia, 2021c). Yet, despite revenues from a $5 fare (factored by annual ridership that peaked at seven million), and multi-million dollar sponsorships of the stations (Chief Marketer Staff, 2004), the LVMC filed for bankruptcy protection in 2010 (Hansen, 2010). Ridership dropped during the Great Recession of 2008; plus, the Sahara Hotel and Casino, at the northern terminus of the line, closed in 2011. One of the station sponsors withdrew its contract in 2008 (O'Reiley, 2012). The Monorail received new life when the SLS Las Vegas (hotel and casino) replaced the Sahara in 2012. The COVID-19 pandemic strained the Monorail in 2020, though, and the LVMC again sought bankruptcy protection. The LVMC finally folded, and ownership was transferred to the Las Vegas Convention and Visitors Authority (LVCVA), as a non-profit corporation.

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The Monorail story reveals the successes and challenges of a public transit system under private ownership. One success is that the Monorail is now over 15 years old, and is a Las Vegas fixture. Granted, the elevated trains operate along a corridor that is behind the Strip, and is not a truly scenic ride (Broadbent failed in his quest to run it down Las Vegas Boulevard). Service continued uninterrupted from 2005 to 2020, despite some financial struggles. Plans to extend the monorail northward to downtown Las Vegas were thwarted by a withdrawal of federal support in the mid-2000s. Plans to extend the monorail southward to McCarran have been thwarted by resistance from limousine and taxi operators, as well as funding issues (Gentry, 2019; Gambling Magazine staff, 2006). Less ambitious plans to add an interim station at the MSG Sphere (located between two existing stations), and a southward extension to Mandalay Bay have been postponed, also because of funding questions. Thus, early on the biggest flaws were technical and structural. Today, the biggest problems are revenue, sponsorships, and financing. Ridership and revenue have ebbed and flowed with the economy, being dependent on tourist dollars. One critic has argued that the Monorail did not "help" the Sahara to stay afloat, thereby shifting responsibility for success to the system's inability to attract enough tourists (Sebelius 2011). Another author (Velotta, 2020) reported on the Monorail executives' high salaries – significantly higher than those of the RTCSN. The LVCVA intended to make salary and other cuts as part of a cost management strategy. While noting the environmental and congestion relief benefits of the Monorail, the LVCVA was taking a frank look at system obsolescence, perhaps within as little as ten years. Other private-public efforts to fund and operate an automated transit system might learn from the Monorail experience, although the uniqueness of the setting must be considered. Fabian noted the many unexplored institutional issues in private sector involvement, and the complex decision-making.

Conclusion

A 2014 collaborative report on automated transit networks, to which Fabian contributed, may have represented the culmination of his decades of writing (Furman et al., 2014). But, his last solo article may best reflect his enduring mindset, at least from a literature perspective (Fabian, 2008). In it, he returns to PRT, tapping into the renewed interest being shown in the 2000s, 30 years after the "PRT fever" decade. As mentioned above, he generally avoided PRT in his writings, preferring to focus on the growing APM industry. The technologies used in APMs are proven, and he excitedly reports on driverless transit systems worldwide, especially in urban applications in Europe and east Asia. He was ever critical of the reluctance to use APMs in urban settings in the U.S. He was jazzed about technological prospects, though, and discusses the potential for PRT in Ithaca, New York – newly being referred to as podcars (Fabian, 2008). Despite the numerous proposed podcar systems that were never built, he was steadfast in his support for podcars, while not shying away from exposing weak concepts. He celebrates advancements in communications and controls, enabling podcar networks to become a reality. He states that age-old problems such as high infrastructure costs, suitable alignments for guideways, and integrating stations with "building lobbies" still exist. These issues, also prevalent with APMs, were not solved during Fabian's stellar career, leaving us to look ahead.

Fabian made at least five deep and lasting contributions to the public transportation literature. First, beyond the catchy descriptions and phrases that he used to attract reader attention, he clearly distinguished APM from PRT, thereby eradicating any confusion over the two transit technologies. Second, he identified three types of APM – architectural, institutional, and mass transit – lending order to an otherwise complex collection of applications, and helping APM planners and analysts to knowledgeably approach their projects. Third, Fabian discussed the potential for airport APM (AAPM) expansion, and established AAPM do-not-build criteria. These have been of great use in comparing and contrasting the multiple, potentially competing modes on an airport's landside – the airfront. Fourth, he finds a place for elevators, escalators, and moving walkways within the overall schema of automated transit. His merging of elevators and APMs as horizontal shuttles, for example, clarifies those applications, and exposes the failure of APMs to deploy more sophisticated, passenger-controlled routing algorithms. Fifth, Fabian avoids mincing words in discussing the shortfalls of APM development in urban mass transit settings in the U.S. The development and nurturing of transit habits, unharried planning, design and construction, government studies that support rather than condemn transit investment, and consistent governmental support for transit projects are all lacking in the U.S. Fabian stops short of offering firm solutions to these problems, but he provides an agenda for future improvements.

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Figure 1. Morgantown PRT (Straight, 2021)

Figure 2. Houston Intercontinental Airport APM (Houston Airports, 2019)

Figure 3. SFO AirTrain (Railway Gazette International, 2019)

Figure 4. DCC Doppelmayr Cable Car (Doppelmayr, 2022)

Figure 5. Elevator Operator in New York City (Bellard, 2021)

Figure 6. Washington, DC Metro (Wikipedia, 2022a)

Figure 7. Miami's Metromover (Alstom, 2021)

Figure 8. Dortmund H-Bahn (Wikimedia, 2022)

Figure 9. Angels Flight Railway, Los Angeles – not an APM (Tripadvisor, 2022)

Figure 10. Slope Car, Japan – not on the APMs list (Wikipedia, 2022b)

Figure 11. Las Colinas APM, Dallas-Ft. Worth (Schneider, 2014)

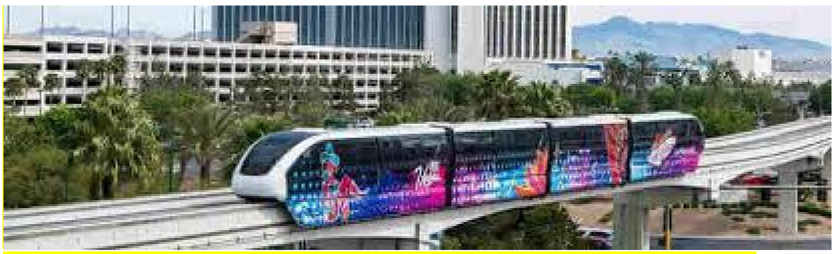

Figure 12. Las Vegas Monorail (Las Vegas Travel Guide, 2022)