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Technological frames and the politics of automated electric light rail rapid transit in Poland and the United Kingdom

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Abstract: Light Rapid Transit (LRT) systems are often backed not only because they satisfy basic mobility functions, but because they can revitalize urban centers, affirm the legitimacy of state planners, support innovation and even cultivate an image of a city or region as progressive and modern. In this study, we argue that electrified, automated LRT systems can fulfill private functional frames, private symbolic frames, societal functional frames, and societal symbolic frames. In particular, we argue that light rail can fulfill private functional frames (making passengers feel safe, offering a cheap and efficient mode of transport), private symbolic frames (signifying political identity or exclusionary planning), societal functional frames (environmental stewardship), and societal symbolic frames (such as modernism or innovativeness). Essentially, these frames encompass not only what light rail is and does, but what it means and represents, and even some of its failures and challenges. The article then identifies ten specific frames associated with two case studies of automated light rail systems, the established Docklands Light Rail (DLR) in the United Kingdom, and the emerging Personal Rapid Transit (PRT) in Poland. We find that the DLR is not only a vital part of meeting (functional) demand for mobility, it is innovative and exciting to ride, legitimization of a conservative approach to project development, a social injustice (to some), an environmentally friendly alternative to cars, and a perceived magnet for global investment into the greater Docklands area. Similarly, the PRT is not only a reliable and safe mode of transit, but also a technical marvel, a monopoly breaking symbol, a clean and sustainable form of mobility, and a reflection of progressive Polish innovation and entrepreneurship (or enduring failure).

Keywords: personal rapid transit (PRT); automated mobility; light rail; light rapid transit (LRT); light rail rapid transit (LRRT); light rail vehicles (LRVs)

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1. Introduction

It is becoming increasingly accepted within the transport studies literature that alternative forms of mobility, such as electric vehicles or light rail transit systems, must satisfy not only basic functions (e.g., a means to get somewhere) and the costs in doing so, but other societal and symbolic dimensions (Sovacool and Axsen 2018). These can include efforts to revitalize urban centers, affirm the legitimacy of state planners, support innovation and even cultivate an image of a city or region as progressive and modern (Enright 2013; King and Fisher 2016; Ramos-Santiago et al. 2016; Taylor et al. 2009; Siemiatycki 2005a; Siemiatycki 2005b).

In this study, we build on this work to argue that systems of mobility—and in particular, a form of Light Rapid Transit (LRT) such as automated electric light rail—fulfills private functional frames, private symbolic frames, societal functional frames, and societal symbolic frames. Based on a qualitative and comparative case study assessment, the article then connects these dimensions of frames to two case studies of innovative automated light rail systems, Docklands Light Rail (DLR) in the United Kingdom, and the Personal Rapid Transit (PRT) in Poland.

In proceeding on this path, the article aims to make three contributions. Firstly, our study looks intently at “frames”—what Lakoff (2004, p. xv) terms “mental structures that shape ... the way we see the world, the goals we seek, the plans we make, the way we act, and what counts as a good or bad outcome.” A large body of research has explored the role of frames concerning technologies, science, policies and social issues, which both reflect and mold perceptions among different social groups and decision-makers (Fischer, 2003; Pal, 2014). Thus, the study shows that light rail can evoke or be interpreted through multiple frames—frames shape how passengers, investors, planners, and other system users are motivated by LRT (or not), their perceptions of it, and how it shapes their lives.

Second, the article examines two very specific, and innovative, forms of LRT, the DLR in the United Kingdom, which features driverless and automated train cars, and the PRT in Poland, which is even more of a frontier technology yet to be fully commercialized. PRT systems in particular have been a contentious transport option within the planning community for at least half a century, dating back to the 1970s and earlier (Vuchic 1996; Latour 1996; Vuchic 2007). They have recently emerged again as a potential low-cost and environmentally friendly option in the context of climate change and other efforts to green the passenger transport sector. Cities in Asia (China, India and Japan), the Middle East (Israel, United Arab Emirates), North America (Canada, Mexico), Western Europe (Austria, Denmark, France, Germany, Poland, Netherlands, Norway, Sweden, Switzerland, and the United Kingdom) and many specific parts of the United States (California, Michigan, Minnesota, North Carolina, Virginia) have all considered it fairly recently with prototypes, concept studies, or pilots (University of Washington 2018; Jaffe 2014; Wood 2013; Price 2012). Transport planners like the ability for PRT systems to reduce reliance on cars, and users like it because of its ability to provide on-demand and private service similar to cars (Jaffe 2014). Yet despite its collective promise, both automated LRT and PRT systems specifically remain seldom studied within academic scholarship.

Third, and lastly, the article uncovers and conceptualizes further the economic, cultural and symbolic elements of LRT, including those featuring emerging innovations such as electrification and automation. Such an exercise is of critical importance, given that UITP (2012) notes 189 light rail and tram networks within the European Union provided some 10.4 billion annual passenger trips that year. LRT systems are credited with having multiple benefits, including being cheaper to construct and build than conventional metros and subways; enhanced accessibility and greater carrying capacity than both trains and buses; better traffic speeds compared to buses and cars; and displaced pollution and congestion from reduced car use (Gadzinski and Radzimski 2016; Olesen and Lassen 2016; Knowles

2007; Knowles 1992; Kołoś and Taczanowski 2016). Knowles and Ferbrache (2016: 371) therefore write “as an option for cities investing in transport infrastructure, modern light rail (tram and light metro) systems can be highly attractive.” Ferbrache and Knowles (2016) add that “LRT clearly has potential to influence sustainable city futures.”

Nonetheless, the benefits to LRT are not predetermined. According to Hodgson et al. (2013), Hall (2011), and the National Audit Office (2004), new LRT schemes must overcome a series of significant barriers, including lack of standards, poor financial performance, and slow planning and approval processes. Knowles (2007) and Knowles and Ferbrache (2016) point out that LRTs are more capital expensive per passenger served than some other modes such as buses. Ferbrache and Knowles (2016) confirm as such, and write that “despite its potential value, light rail has not always been as well developed, based on competing ideas of sustainability, and the need for integrated planning and transport investment.”

As such, critically examining the development of LRT systems helps reveal the coevolving nature of technology and infrastructure with mobility patterns as well as user preferences, forms of planning, and business models. This all suggests that LRT projects need to be rethought as complex urban development projects instead of just simple “pieces of infrastructure” (Knowles and Ferbrache 2016; Olesen and Lassen 2016). Here we critically unpack such dimensions through our exploration of the frames connected to two distinct LRT case studies, the DLR in London and the PRT in Opole, Poland.

2. Mobility frames, case selection and data collection

We begin by first defining our notion of a “frame” and then explaining our selection of two case studies, the DLR in the United Kingdom (UK) and the Personal Rapid Transit (PRT) system in Poland.

2.1 Conceptualizing mobility “frames”

In the broadest sense, a frame is simply a way of organizing experience (Goffman 1974). The notion of a frame has been influential across a variety of disciplines, from artificial intelligence and communication theory to psychology, innovation studies, public policy, and sociology. Berkout (2006: 307) notes that a frame is seen both as “functional to interpretation, sense-making and problem-solving by social agents, and to establishment and maintenance of cohesion and order of social groups” as well as “a means for reconciling experience with knowledge.” In the social construction of technology literature, a “technological frame” refers to “all elements that influence the interactions within relevant social groups and lead to the attribution of meanings to technical artifacts” (Bijker 1997, p. 123). Put in simpler terms, a technological frame refers to a shared cognitive worldview that binds different stakeholders together, meaning it is external to any individual or sociotechnical system. Klein and Kleinman (2002, p. 31) add that a technological frame can deeply penetrate stakeholder perceptions of technology, structuring their thinking, influencing problem solving, shaping the formulation of strategy, and even altering design specifications. In sociology, frames refer to “ideological tools that organize experience, diagnose problems, and prescribe solutions” (Babb 1996: 1034). *Frame resonance* occurs when a particular frame is effective at convincing its target audience; *frame bridging* or *alignment* to when separate frames coalesce around a given problem (or in our case, technology) (Snow et al. 1986; Snow and Benford 1988; Benford 1993). Indeed, our two case studies below of the DLR and PRT reveal a collection of ten distinct frames connected to light rail rapid transit (LRRT) systems.

To guide our assessment of frames for light rail, we relied on an approach arising from transport studies suggesting that automobility, the sociotechnical system behind the internal combustion car or substitutes to it such as electric vehicles, can fulfill symbolic as well as functional attributes across

private and societal dimensions. Specifically, Axsen and Kurani (2012) propose that consumer perceptions of electric vehicles can be divided into a two-by-two dimensional typology depicted in Table 1: functional versus symbolic, and private versus societal. The functional aspects of electric vehicles are important, where consumers may want a passenger vehicle to be practical, but they do not capture the full range of other frames touching on symbolic and societal scales.

Table 1. Functional-Symbolic and Private-Societal frames of electric vehicles

	Functional Frame	Symbolic Frame
Private Frame	What it does for you, e.g. <ul style="list-style-type: none"> • save money • reliable • efficient 	What it represents, e.g. <ul style="list-style-type: none"> • Expression of self-identity • Convey personal status • Attain group membership
Societal Frame	What it does for society, e.g. <ul style="list-style-type: none"> • Reduce air pollution • Reduce global warming • Reduce oil use 	What it says to society, e.g. <ul style="list-style-type: none"> • Inspire other consumers • Send message to automakers • Send message to national planners

Source: Adapted from Axsen and Kurani (2012); Sovacool and Axsen (2018)

While Axsen and Kurani (2012) and Sovacool and Axsen (2018) examine this typology within automobility (and innovations such as electric mobility, automatous passenger vehicles, and ridesharing), here we apply such a typology to LRRT, at times also called light rail vehicles (LRVs), trams, and metros (UITP 2012). The European Conference of Ministers of Transport offers a definition of light rail as “rail-borne form of transport which can be developed in stages ranging from the modern tram to a rapid transport system operating on its own right of way, be it underground, at ground level or elevated” (Kotos & Taczanowski, 2016). Kołós and Taczanowski (2016) add that the term “light rail” can denote any type of rail-based network that is not “heavy” i.e. traditional trams, fast trams which are

separated from road traffic, tram-trains and hybrid solutions. The adapted frames for light rail are presented in Table. 2.

Table 2: Functional-Symbolic and Private-Societal frames of light rail rapid transit

	Functional Frame	Symbolic Frame
Private Frame	What it does for an individual, e.g. <ul style="list-style-type: none"> • Efficient transport • Safe and secure mobility • Affordability mobility 	What it represents, e.g. <ul style="list-style-type: none"> • Form of innovation or excitement • Affirmation of political stance • Injustice of planning
Societal Frame	What it does for society, e.g. <ul style="list-style-type: none"> • Reduce traffic congestion • Reduce climate change • Reduce air pollution 	What it says to society, e.g. <ul style="list-style-type: none"> • Inspire other communities • Symbol of modernism or progressiveness • Send message to investors • Symbol of perpetual failure

Source: Authors

2.2 Case study selection and research methods

To illustrate the complexity of frames associated with LRT, we selected two case studies, the DLR in the United Kingdom, and the PRT in Poland. Table 3 offers a summary of these different systems. Our two case studies have the added distinction of being both automated (and driverless) as well as fully electric.

Table 3: Comparing the basic features of the DLR and PRT automated light rail systems

	DLR (UK)	PRT (Poland)
Date commissioned	1987	2007
Length of track	Original: 13km Present: 31km (19.4 miles)	Original: 1km Future: 33.8 km (21 miles) to be developed later
Initial cost (total)	£77 million	\$10 million (for first km)

Initial cost (per km)	£6 million (based on the first phase construction: 13km, 13 stations)	\$40 million for next 5 km of track (MISTER 2008)
Type of vehicles	Bombardier types B90/B92/B2K	Metrino-Pod
Costs per unit	£14 million based on a new deal (RTM, 2018)	€16k (Mikosza, 2014)
Initial ridership (annual passengers)	6.7 million (1987)	Still at prototype stages
Current ridership (annual passengers)	122 million (2017)	Not in-service
Initial or projected size (number of stations, track length, number of trains/cars, passenger volume)	15 stations, 11 single-car electric multiple units (1987) 284 (70 seated) per fleet	Highest capacity: 100 pods in 1km of 2-way track 5 passengers per pod
Current size (number of stations, track length, number of trains/cars, passenger volume)	45 stations, 56 Bombardier- three-car trains with 149 individual units, 24 miles of track	Not in-service
Total cost (total)	At least £277 million	Not yet implemented
Total cost (per km)	£35 million	€5 million
Integrated with other transport nodes	Yes	No
Level of maturity	Fully demonstrated	Under testing and development
Innovation dynamics	Government/state led, project-based learning, systems integration, web of firms with integrator at the center	Market led, machinery, in-house product design with close link to users

Source: Authors compilation

To explore our two cases, we chose a qualitative, historical methodology because this is well suited for rich and processual studies of phenomena in real-world contexts (Yin 2014). The DLR and PRT were chosen because they constitute contrasting cases along multiple dimensions. We believe the case study literature would call our approach a mix of “typical” yet “diverse” cases (Sovacool et al. 2018). *Typical* case studies study common, frequently observed, and/or representative cases, and exemplify a stable, cross-case relationship. *Diverse* cases attempt to demonstrate maximum variance along a relevant dimension, so that they illuminate the full range of important differences. Our two cases are therefore typical (both involving the development of an automated LRT) but not identical, as

they vary in some of their features (innovation approaches, technical features, location, historical development).

In the first step of our research process, we compiled a large body of secondary literature—peer-reviewed articles, company reports, market assessments—on the two LRT systems. In the next step, we reduced the material to its core contents by writing in-depth case studies on each of the two cases (Mayring 2014: 66). We then used qualitative analysis (Yin 1994; Blatter and Blume, 2008) of our data applying the categories of our conceptual framework. In the last step, we assessed the similarities and differences between the two cases to capture varying frames surrounding each of the LRT innovations.

The next two sections elaborate further on these cases, beginning with a justification as to why each is worth exploring, then teasing out its historical development before moving to a discussion of current technical infrastructure, actors and networks, and policies. The penultimate section translates the case study findings into those of competing frames.

3. Docklands Light Railway (DLR) in London, United Kingdom

Sometimes called a “super tram,” the Docklands Light Railway (DLR) network in the United Kingdom (UK) is an automated light rail system (Knowles 2007). It can run on track integrated into streets, converted railway lines, or new alignments; can manage steeper gradients and tighter curves than trains; and operate driverless vehicles (Knowles 2007; Knowles and Abrantes 2008). Statistics from the Department for Transport (2017) shown in Table 4 confirm that the DLR is the largest (by far) of all LRT systems in the UK, with 122.3 million passenger journeys that year. Stephen and Price (2017) conclude, due to its number of passengers carried, “DLR has become one of the UK’s highest performing railways”.

Table 4: Annual rail passenger journeys, vehicle miles, and revenue in the UK, 2016/2017

	Passenger journeys		Vehicle miles		Passenger revenue	
	2016/17 figure (m=millions) and change compared with the previous year				Revenue % change in 2016/17 prices	
England	267.7m	⬇ 6.2%	21.6m	⬇ 2.9%	£362.4m	⬇ 5.5%
London systems	151.8m	⬇ 5.5%	5.7m	↔ 0.0%	£195.9m	⬇ 4.0%
Docklands Light Railway	122.3m	⬇ 4.6%	3.8m	↔ 0.0%	£170.4m	⬇ 3.2%
London Tramlink	29.5m	⬇ 9.3%	2.0m	↔ 0.0%	£25.5m	⬇ 9.6%
England outside London systems	115.9m	⬇ 7.2%	15.9m	⬇ 4.0%	£166.5m	⬇ 7.3%
Nottingham Express Transit	16.4m	⬇ 35.0%	1.9m	⬇ 19.5%	£17.8m	⬇ 28.1%
Midland Metro	6.2m	⬇ 29.0%	1.2m	⬇ 10.7%	£10.3m	⬇ 17.6%
Sheffield Supertram	12.6m	⬇ 9.0%	1.5m	⬇ 4.5%	£13.5m	⬇ 16.2%
Tyne and Wear Metro	37.7m	⬇ -6.5%	3.5m	↔ 0.0%	£50.5m	⬇ -1.3%
Manchester Metrolink	37.8m	⬇ 10.2%	7.2m	⬇ 1.0%	£67.3m	⬇ 5.8%
Blackpool Tramway	5.1m	⬇ 3.9%	0.6m	⬇ 9.2%	£7.1m	⬇ 15.4%

Source: Department for Transport (2017)

While accounts vary, one can trace the genesis of the DLR back to at least the 1960s. Then, the 1968 Transport Act prompted substantial investments in rail with financing offered by government grants. Initially this culminated in several heavy rail schemes, including the Liverpool “Link and Loop,” Glasgow’s “Argyle Line,” and Underground refurbishment schemes (Lee and Senior 2013). Plans for a particular LRRT within London began to surface in the 1970s. In a scheme proposed by the Conservative minister Michael Heseltine, the London Docklands Development Corporation (LDDC) was set up to operationalize a series of earlier plans, studies, and working group findings in 1981. This took planning (zoning) powers away from the five London boroughs, and it guaranteed companies moving in relief from local taxation for a fixed period. At the time, Margaret Thatcher’s government was actively supporting efforts to tempt large companies to relocate to the Docklands area, and it saw the DLR as a cheaper alternative to extending London Underground’s Jubilee Line. A £77m contract was subsequently agreed in August 1982, with a joint venture comprising GEC and Mowlam for construction (Stephen and Price 2017), and paid by government. After some debate about possible street running, the LDDC voted for “an automated mostly-elevated system, using in part abandoned freight railway alignments. Construction started in 1984, and the railway opened in 1987 with 11 trains

(shown in Figure 1) and 15 stations (Stephen and Price 2017). As of 2017 the DLR has grown to 45 stations shown in Figure 2 and a stock of 149 vehicles.

Figure 1: P86 Bombardier, DLR passing at Poplar bound to Stratford, 1987

Source: Transport for London

Figure 2: DLR Routes Network, 2017

Source: Transport for London

As Table 5 reveals, the DLR involved during its developmental phase (and continues to involve via its stability phase) a constellation of actors including various bodies within national government (political parties, Labour, Conservatives), the LDDC, and constructing and engineering companies such as GEC and Mowlam, Linke-Hofmann-Busch (now Alstom), and Bombardier. Note that there were significant political and governance changes between the 1980s and the 2000s. In 1986 the GLC was dissolved by the national government, and its responsibilities allocated to the London Boroughs. In 2000, a London-level government was re-instituted by the Labour national government, in the form of the GLA and London Assembly, which took back control of London Transport. Perhaps the most important actor of all, customers or users, seem satisfied. Stephen and Price (2017) report that 99.5% of DLR trains ran on time and that 89% of passengers said they felt satisfied at the end of their journeys in the latest satisfaction survey. The international visitors of London might be considered as international actors or customers; e.g. DLR was crucial to the success of the London 2012 Olympic and Paralympic Games (Transport for London, 2018).

Table 5: DLR Actors and Networks

a. Top panel: development phase

Actor	Description
Central Government	High level power in decision making for Docklands renewal
London Dockland Study Team	Commissioned by the central government to undertake a strategic assessment of the economic problems and potential of Docklands, resulting in a series of five options presented for debate.
Docklands Joint Committee (DJC)	Established by including representatives from the five local boroughs, the Greater London Council (GLC), the Department of the Environment (DoE), and the local community (later replaced by the LDDC)
Department of the Environment (DoE)	Membered in DJC by a representative
Greater London Council (GLC)	Membered in DJC by a representative
Local boroughs	Representatives of five local boroughs membered in DJC

Local community	Representatives of local community membered in DJC but not LDDC
London Dockland Development Corporation (LDDC)	Created by Government as an urban development corporation to replace the DJC. Board members were appointed by the Secretary of the State for the Environment.
Docklands Consultative Committee	Oppositions against negative externalities and use of lands

b. Bottom panel: Stability phase

Actor	Description
Greater London Authority (GLA)	London assembly (elected 25-member) plus the Mayor of London
Mayor of London	Elected by popular vote
Transport for London (TfL)	One of the GLA group of organizations, accountable to the Mayor, with responsibility for delivering an integrated and sustainable transport strategy for London
Department for Transport (DfT)	Government department responsible for the English transport network
Network Rail	The owner and infrastructure manager of most of the rail network in England, Scotland and Wales
Training Operating Companies (TCOs)	Firms that provide rail passenger services, leasing and managing stations from Network Rail. TOCs normally lease trains from rolling stock companies.
Transport Infrastructure Providers	Private sector
Service Operators	Private sector
Passengers	End-users

Source: Compiled by the authors

The trajectory of the DLR was buttressed by multiple policies at various scales. Here, as Table 6 summarizes, a long history of policy support exists, going back to the seminal 1968 Transport Act and calls for the revitalization of the Docklands as early as 1971. Even after the DLR became operational in 1987, we see a mix of numerous supportive policies and regulations that have coevolved with the technology.

Table 6: Development and policy timeline for the DLR

Year	Description
1968	Transport Act
1971	Redevelopment plans of central government

1973	London Docklands Study Team
1981	London Docklands Development Corporation (LDDC) created by Government under Local Government, Planning and Land Act 1980
1982	Government approval for DLR construction
1986	First phase runs
1987	Royal opening by Queen Elizabeth II
1988	6.7 million passengers carried by DLR in its first year
1991	Extension opened to Bank
1992	23 B90 units enter service
1994	Extension opened between Poplar and Beckton, where new depot opens
1995	47 B92 units enter service
1997	Docklands Railway Management Ltd becomes franchise operator, owned by Serco
1998	LDDC finished its work and ceased to operate on 31st March 1998 and was wound up three months later
1999	Lewisham extension opened
2002	24 B2K stock units enter service
2004/2008	London Plan (in original and revised forms) establishes the Isle of Dogs and DLR area as one of “opportunity” and seeks to increase growth
2005	London City Airport and North Woolwich extensions open
2006	New franchise awarded to Serco Docklands
2009	55 B07 stock units enter service, extension opened to Woolwich Arsenal
2011	Extension opened to Stratford International
2012	12m passengers carried during London Olympic Games
2014	KeolisAmey Docklands becomes franchise operator
2017	The new London Plan; The Spatial Development Strategy (SDS) for Greater London and the Mayor’s Transport Strategy to 2041 open for public consultation
2018	Mayor’s Transport Strategy is published for long-term 2050 outlook. DLR aims for upgrading structure to increase capacity, improve frequencies, and improve reliability. Confirms replacement rolling stock project and extension to Thamesmead

Authors compilation, modified from Taplin 2010; Transport for London 2015; Stephen and Price 2017; Mayor of London, March, 2018.

Despite such a diverse group of actors, with shifting responsibilities, and a mosaic of policies, the DLR has been able to attract resources and further growth. London Mayor Sadiq Khan unveiled his draft Transport Strategy in June 2017, published in March 2018, which firmly placed new transport infrastructure as the cornerstone of London’s future prosperity and world status (Stephen and Price 2017). The Transport Strategy argued that a steady pipeline of enhancements, including extensions to the DLR, would help create 1.2 million more jobs by 2041, while supporting the construction of 50,000 much-needed new homes each year. Thus, the Mayor of London (2018: 112) stated in Proposal 68 that:

“Transport for London will increase the capacity of the existing Docklands Light Railway network by 120 per cent by 2041 through the introduction of a new higher capacity train fleet and improved frequencies (towards 30 trains per hour across more of the network), accompanied by greater station capacity at major development sites and transport interchanges”.

4. Personal Rapid Transit (PRT) in Opole, Poland

The Personal Rapid Transit in Opole, or the PRT, is markedly different from the DLR—and due to its prototype nature, much less information is available about it. The PRT is a public transportation mode featuring small, automated vehicles operating on a network of specially-built guideways in Opole, Poland. PRT systems as a whole are said to have numerous potential advantages. As Price (2012) notes, they are convenient because they can shuttle users to destinations directly without stopping at intermediate stations. They can be powered by cleaner fuels such as renewable electricity. They can fit into extremely dense urban areas because their pods can be small and have shorter turning radii. They can also solve the “last mile problem” of getting people from larger hubs to their homes or smaller final destinations.

The PRT in Poland uses proprietary technology known as Metropolitan Individual System of Transportation on an Elevated Rail, or MISTER, a type of automated guideway transit. The PRT system in particular uses automated pods to deliver passengers from station to station. In PRT designs, vehicles are sized for individual or small group travel, typically carrying no more than 3 to 5 passengers per vehicle with a switchless guideway (Choromaski et al. 2013). The point-to-point service has been compared to a taxi, albeit one running along a fixed rail line. Figure 3 shows the main centerpiece of the PRT, it’s “pod”. In September 2007 a prototype of the system was built in Opole, and its current status is that a 1 km test track is operational. After this pilot phase, plans (as of 2017) call for the full urban network to be developed—spanning at least 20 km (Eltis 2017).

Figure 3: A PRT Pod in Opole, Poland

Source: PRT

Table 7 offers a concise history of the PRT's development, which began in earnest only in 2005. A longer history of the PRT can be traced back to the 1960s, when Donn Fichter first proposed its concept in a book. At this time, almost all Polish rail transport operated as a monopoly, with one national carrier (Polish State Rail, or PKP) using almost the whole network (Taylor and Ciechański 2006). The PRT is a noteworthy exception to this trend, albeit one at only an early stage of development (Department of Rail and Public Transportation, 2009). Opole is a member of the European Union CityMobil Reference Group of Cities (Alessandrini, et al., 2008). In this regard, the PRT was granted much-needed matching funds of \$10 million from European Union High Tech Fund for the development of a testing facility (Metrino-PRT, 2018).

Table 7: Development timeline for the PRT light rail transit system

Year	Description
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1964	Donn Fichter's book <i>Individualized Automatic Transit and the City</i> published
1970s	Fitchter's and similar ideas coalesced around the name "Personal Rapid Transit"
2005	Ollie Mikosza files first patent application
2007, September	A full-scale prototype is built for the city of Opole in Poland
2007, July	The Opole mayor and city council signed letters of interest indicating their willingness to expand the PRT in the city with 21 miles of track
2012	Letter of intent for PRT construction issued by municipality of Krakow for MISTER PRT co. (Metrino Global Project Ltd. Co)

Source: Authors compilation from (Floyd, 1990); (Mikosza & Cottrell 2006); (Metrino-PRT, 2018).

In terms of national policy, the 2003 Rail Transport Act radically transformed the national Polish rail sector, seeking to better align it to EU principles (Taylor 2004). Although it by and large protected the monopoly rights of the PKP, it did allow for two exceptions: independent operators can serve passenger traffic if they keep a separate system of accounting, or if they use a railway not accessible by other operators. Table 8 offers a more detailed summary describing particular developments in European, Polish, and PRT policy.

Table 8: The evolution of PRT Policy

Period	European Policy		National Policy (Poland)		PRT Policy/development (Opole)	
	Transport	Cohesion/Spatial	Transport	Spatial/Regional	Transport	Spatial/Regional
2001–2011	White Paper	EU enlargement in 2004	Transport policy subordinated to the use of EU funds	Concept of the Policy of the National Spatial Development	Between 2006, May and 2011, April, CityMobil project funded from European 6 th technological development and demonstration Framework Programme	Opole's PRT launched
	TEN-T priorities without enough financial support for their realization.	Accessibility studies (ESPON), EU Territorial Agenda	Reactivation of road investments	Priority for international transit investments	Decarbonisation, Societal/Economic issues	Vehicle design and manufacturing
		Territorial Cohesion in the Lisbon Treaty	Lack of prioritization of projects		FP6-SUSTDEV-3 Funding Program	Funding for low-emission alternative energy for transport
		Accessibility as a measure of				

		European cohesion (Cohesion Reports)				
2011+	Revision of TEN-T guidelines	New cohesion policy rules (thematic concentration, conditionality, result-oriented efficiency)	Transport Development Strategy. Evaluation of investment projects	National Spatial Development Concept 2030	-	-
				Hierarchy of priorities. Priority for domestic investments.		
		EU Territorial Agenda with priorities	Priority to effective and multimodal links between:	Policy implemented through accessibility measures		
			European network, Warsaw, regional (and subregional) centers, areas with specific assets and development potential, rural areas and borderland areas.	Focused on mutual accessibility of major urban areas, access to cities and regions in the European context, access to sub-regional centers and rural areas, access from areas with the poorest time accessibility to major cities.		
				Regional accessibility improvement as an objective in the Voivodeship Development Strategies.		

Source: Authors compilation, modified from Rosik et al. 2015 and <https://trimis.ec.europa.eu/project/towards-advanced-road-transport-urban-environment>

5. Discussion: competitive frames and comparative insights

Above, we conceptualized that automated LRRT systems can fulfill private functional roles (making passengers feel safe, cheap and efficient mode of transport), private symbolic roles (signifying political identity or exclusionary planning), societal functional roles (environmental stewardship), and societal symbolic roles (such as modernism or innovativeness). Interestingly, Table 9 demonstrates that we see all of these frames at play with the DLR and PRT. When building the narratives around

each frame, the study relies on a mix of academic and popular media sources such as direct quotations from a variety of stakeholders including inventors and designers, financiers, planners, and users.

Table 9: Functional-Symbolic and Private-Societal Frames of the DLR and PRT

	Functional	Symbolic
Private	<ul style="list-style-type: none"> • DLR: vital part of meeting demand for mobility • PRT: safe, reliable and cheaper than traditional LRT 	<ul style="list-style-type: none"> • DLR and PRT: Innovative and exciting forms of transport • DLR: Legitimation of political approach to development • PRT: Challenge to the monopoly based national rail system • DLR: Affront to due process and principles of justice
Societal	<ul style="list-style-type: none"> • DLR and PRT: environmentally friendly alternative to cars 	<ul style="list-style-type: none"> • DLR: harbinger of investment and economic revitalization • PRT: image of economic modernism • PRT: enduring symbol of failed transport planning

Source: Authors

5.1 Functional-private frames: cheap, efficient, and safe mobility

The functional-private frames for our two LRRTs are perhaps the most conventional and expected: they are framed (rightly or wrongly) as a vital part of meeting growing demand for mobility (DLR) or a utilitarian, safe, and cheap form of transport (PRT).

DLR: vital part of meeting demand for mobility

This frame connects to what the DLR was designed and intended to do: provide mobility, especially to commuters, within London, and serve as a vital spoke of a broader integrated transport

master plan (Carmona 2009). The DLR was never intended to exist in a vacuum, and when designed in 1981 planners noted that it would serve a crucial, integrative function with other forms of transport in the Docklands, including roads, buses, air travel (the opening of the London City Airport in 1987) and even river travel on the Thames.

Under this view, the DLR is another piece of light rail, albeit a purportedly vital one. It is also one set to expand further in fulfilling this frame (Railway Technology 2018; IanVisits 2017). Stephen and Price (2017) note that current expansion plans include the proposed ordering of 43 new trains and a strengthening of services across the Royal Docks area given the expectation of 25,000 new homes and 60,000 new jobs by 2022. The Mayor of London (2017, 2018) has also called for a modal shift so that at least 80 percent of traffic in London is diverted to rail by 2041. Figure 4 shows what the full extent of the DLR could be if all extension plans come to fruition.

Figure 4: Potential DLR extensions, 2011-2041

Source: Mayor of London (2009)

PRT: reliable, safe and cheap

Although only a prototype, the dominant frame of the PRT is also one of rather conventional safe and cheap transport. Early promotional material for the PRT (MISTER 2008) described it in terms of being “functional” and “inexpensive to build and operate,” noting that it could reach average speeds of 50 kilometers an hour but that it also had a host of other functional benefits, including:

- Stability: being suspended, PRT pods cannot fall over
- Footprint: having no ground level tracks, less real estate is required
- Capacity additions: Ability to add stations and intersections without modifying existing tracks
- Integration with the urban environment: High climb/descent angles (45 degrees) means it can avoid buildings
- Accessibility: Easy provision for wheel chair, baby carriage and bicycles access to all vehicles at all stops, with a level floor at all times and no seatbelts necessary

MISTER (2008) even claimed in one presentation that the PRT offered planners an “anti-terrorist structure,” due to “target dispersement,” and well as “anti-flooding” infrastructure, since it operates 6 meters or more above the ground. When discussing the merits of MISTER technology, the development team has been quick to stress how it avoids “rapidly growing stress resulting in accidents and assaults” and reduces conventional “pressure on existing [transport] systems, which cannot be met economically,” therefore stopping a drain of public funds (MISTER 2008). In addition, the rather utilitarian calculations of cost, speed, and capacity arise when the PRT is compared to other transport modes, as Table 10 indicates, although in a seemingly (and perhaps overly) optimistic manner. When normalized by passenger volume and cost, its inventors claim that the PRT is sixteen times more effective than a subway or conventional light rail, 12 times more effective than buses, and 10 times more effective than trams. The PRT is thus framed—rightly or wrongly—as having very limited risk

and cost compared to investing in current solutions like parking lots, buses, and traditional rail infrastructure.

Table 10: Projections of PRT cost and performance compared to buses, trams, and conventional light rail

	Bus	Tram	Conventional light rail/subway	PRT
Total cost of 1 km of track/road	\$15 million	\$20 million	\$150 million	\$8 million
Average peak speed	10 km/h	15 km/h	30 km/h	50 km/h
Maximum number of passengers on 1 km track/road	400	400	1000	500
Maximum throughput per direction per hour	2,000	3,000	15,000	12,500
Maximum network capacity	80,000	120,000	600,000	500,000
Normalized system effectiveness (for same cost)	1.3	1.6	1	16

Source: Modified from MISTER (2008).

5.2 Symbolic-private frames: political legitimacy and an insult to justice

Symbolic-private frames range from four positive ones of technical innovation, political legitimacy, and monopoly breaking to one negative one of injustice.

DLR: Innovative, exciting, and fun to ride

The DLR represents a technical innovation, or indeed, multiple overlapping innovations, the most obvious of which is automation. Ferbrache and Knowles (2016) characterize DLR as a “driverless lightweight metro,” Taplin (2010) notes it was the first automated (or driverless) light rail in the world. Stephen and Price (2017) comment that the DLR remains well-known for its driverless operation, also called “UTO” or “Unattended Train Operation”.

These technical specifications all culminate in individuals preferring to ride the DLR because it is innovative, thrilling, and exciting. Early marketing material for the DLR, shown in Figure 5, urged people to use it not only for utility, but to take in the “breathtaking views” of the city. As one rider put it:

The novelty of sitting in the ‘driver’s seat’ feeds the imagination of kids and excitable adults alike. As the DLR darts past eye-catching skyscrapers, it’s an experience akin to riding a rollercoaster or a monorail (Time Out London 2017).

Another tourist magazine put riding the DLR in the list of “top ten” things to do in London, writing that:

It is perfectly acceptable to push kids out of the way to be able to sit at the front and pretend you’re the driver. They’ll get their chance when they’re older and stronger. This is your time and you are getting this goddam train to its destination. Pro tip, it’s 100% worth sitting at the back of the train, going in the opposite direction to the way you ultimately want to go, getting to the terminus, and then claiming the throne at the very back, which becomes the front when it goes back the other way (Fawbert 2017).

Connor (2016) also suggested that the driverless nature seamlessly interconnected with the excitement of riding, added that:

What’s perhaps most incredible about this system, other than the fact that sitting at the front feels like riding on a rollercoaster, is that it’s London’s first and only driverless train system of its kind.

One columnist (Elledge 2017) even remarked that:

The tiny trains and sharp corners place [the DLR] somewhere between a toy train set and a rollercoaster, and most of the time its trains don’t even need a driver, but pootle about with minimal input from the on-board guards. It’s incredibly, magnificently strange, the sort of railway Harry Potter would use.

These statements, albeit anecdotal, all support the notion of riding the DLR not only for its functional attributes, but because it is fun. (Granted, for workers in the area, the thrilling nature of it is likely minor compared to modal tradeoffs in terms of the utility of just getting to your job).

Figure 5: Promotional material for the DLR in 1987 and 1994

Source: Archives of the London Transport Museum.

PRT: a technical marvel radically challenging conventional public transport

Similar connections to innovativeness, or even radical innovation, feature in discussions of the PRT. It, like the DLR, entails multiple technical innovations. As mentioned previously, the PRT uses small, automated vehicles on an elevated guideway. It departs on demand without any timetable, and its propulsion systems and motors are electric, including on-board power with batteries, Linear Induction Motors, magnetic motors, and a conventional drive system (MISTER 2008). For perhaps these reasons, MISTER (2008: 14) claims that the PRT “provides a quantum leap in all performance parameters, function, quality and cost factors compared to existing systems, including private cars”. SciTech Poland (2017) argue that the PRT is also adaptable based on user feedback, with users reconfiguring the system

to adapt to their needs via a website. And while it is private or at least personal, it remains a public transport (the vehicle system is used by many different users). This leads them to call the PRT a “new and highly innovative solution” to Polish transport. The points about the PRT being on-demand rather than timetabled, and the option to miss out intermediate stops that fall on the way to your destination stop, appear to be the most innovative elements.

DLR as conservative political legitimacy

This frame envisages the DLR not as a functional mode of transport or a technical marvel, but legitimacy for the political parties (and arrangements) supporting it. The DLR was a testbed for private sector involvement in large scale public service infrastructure. At the time it was conceived, British Rail was nationalized and publically owned, and London buses and the tube were operated by London transport, which was controlled by the GLC. The DLR was part of Conservative government approach to infrastructure—often espoused by Margaret Thatcher—intended to show that if you make the conditions right the private sector can deliver everything the public sector can and better (Carmona 2009). In this way, the DLR legitimated the neoliberal philosophy behind the Conservative party’s approach to government, including a fundamental ideology that the public sector could and should not take sole responsibility for delivering infrastructure, and that more market-based measures were needed to counter the inadequacies of conventional land-use planning (Carmona 2009).

Thus, when it was launched, the LDDC (behind the DLR) became praised as model, a quasi-autonomous non-governmental organization, or QUANGO, an ideal template for project financing and partnerships for “all of Britain” (Church 1988). The DLR represented a drastically novel approach to project financing and governance (Carter 1991). At this time, plans hailed the DLR as *the* crucial piece of efficient, inexpensive infrastructure linking, one heralded by the Thatcher Government as a sign of things to come (Church 1990).

PRT as a monopoly breaking political symbol

The PRT is framed as having a similarly political angle, although one more specific to the Polish system, as it is done entirely outside of the nationalized sector. In Poland, the financial source for construction and modernization of state important railways (in total 12000–15000 km, depending on the source given) has been provided by the state budget, to be operated by Polish State Railways (Taylor 2004). However, over the past few decades the Polish transport system has been subject to “profound political and economic changes” since the 1990s, leading many rail operators to bankruptcy (Pucher and Buehler 2005) and creating a vacuum for private actors to fulfill (Taylor and Ciechański 2006). A defining aspect of the Polish transport policy is that the state has almost wholly withdrawn from urban policy development. As such, it has created a space for innovations such as the PRT to emerge and break both the monopoly and stagnation of national rail policy. National rail actors were also accused of colluding to keep prices high and to block new entrants from challenging their control over the Polish rail system (Carbajo and Sakatsume 2004). In this way, even in its prototype stages the PRT symbolizes a compelling alternative to the existing monopoly model in Poland for passenger rail.

DLR as a social injustice

A final symbolic-private frame suggests that the DLR itself represents a gross injustice. This frame touches upon two themes, lack of participation and inclusion in planning (procedural justice), and unfair distribution of costs and benefits (distributive justice).

In terms of procedural justice, contrary to the frame of conservative political legitimacy, this frame depicts the DLR as a flawed attempt at popular planning subject to a tokenistic form of wider public consultation (Carmona 2009). Thus, the DLR symbolized—to some—a failure to engage local interests and representatives, by removing the process from local control. Despite a labor clause attempting to prioritize local employment on DLR construction teams, it had virtually no effect; less

than 1% of workers were residents of Docklands (Church 1988). Furthermore, the £240 million DLR extension to Beckton was financed partly by selling adjacent publicly owned land—but without the full consent of the broader public (Knowles and Ferbrache 2016). Smith (1989) goes so far as to critique the DLR for promoting “instruments of social control” that were exclusionary and anti-democratic in nature. As he wrote: “The local population have lacked any existing ‘democratic’ means through which to express their views”.

In terms of distributive justice, while hailed a success by many, the DLR was supposed to be a precursor to many more benefits and plans that did not materialize (Knowles and Abrantes 2008). In this sense, the DLR can be interpreted a failure. Also, as the DLR increased house prices beyond the reach of local people, it has been criticized for reinforcing unequal demographic and social patterns in an already unequal society (Church and Frost 1998; Church and Frost 2000). One problem with demand-led transport planning in Docklands relates to the predictable clash between the needs of the market, as expressed by developers and employers, and the needs of local communities (Church 1992). Thus, according to this frame, the DLR itself not only provided mobility; it reflected a bitter affront to social justice.

5.3 Functional-societal frames: environmentally friendly alternative

Unlike the diversity of symbolic-private frames, the functional-society frames had more coherence with each other. Both emphasized the positive environmental benefits of the DLR or PRT as an alternate to conventional cars.

DLR: environmental alternative to cars

Like most industrialized countries, the UK remains arguably committed to a transport planning paradigm favoring privately owned, internal combustion automobiles. Hasiak and Richer (2012)

emphasize that road investments fit into a general model of “predicting and providing,” which is to mean forecasting future demand for cars and roads and building out to meet those projections.

However, LRRT in general, and the DLR in particular, was proposed as a way to simultaneously reduce traffic congestion and improve environmental sustainability. In 2000, the new Mayor, Ken Livingstone, went so far as to claim that if the expansion of London as a global financial capital was to be successful, it needed to achieve an urban renaissance. A centerpiece of this was expanding the DLR. Following its extension, a National Audit Office Report (2004) conceded that light rail (and the DLR explicitly) had improved the quality and choice of public transport, achieved modal shift from cars and enhanced the image of their host cities. Hodgson et al. (2013) adds that a major part of UK transport policy has been to attract car users as part of transport demand management and to reduce transport’s environmental impacts. The DLR did achieve this goal – according to Steer Davies Gleave (2005), prior to 1997, almost a quarter of travel to work in the Isle of Dogs was by car, but by 2005 fewer than 11% of Canary Wharf employees arrived by private vehicles and 89% used public transport, cycled or walked.

Thus, this frame sees the DLR as an environmentally friendly alternative to cars, one ridden by those concerned about reducing their environmental footprint. As Richard De Cani, DLR Head of Development and Planning, noted in 2007:

[The DLR] has brought real environmental benefits with people opting to use the DLR when travelling to the airport, instead of relying on cars and taxis, and has therefore made a huge impact in cutting harmful carbon dioxide emissions. (Transport for London 2007).

As Boris Johnson (2009), former Mayor of London commented, because of the DLR:

Canary Wharf is now one of the most sustainable locations in the Capital in terms of travel demand with very high levels of public transport use and low car use.

Indeed, a study commissioned by Transport for London (2007) suggested that the DLR extension to London City Airport alone displaced about 120,000 taxi rides and 288,000 car journeys to the airport, with a consequent reduction in greenhouse gas emissions. The report also noted that of those travelling to London City Airport, 49 percent had gone by the DLR, the highest proportion carried by any airport rail link in the UK.

PRT: clean and environmentally sustainable form of transport

An almost identical frame of environmental sustainability buttresses the PRT, where it is depicted as a cleaner and more efficient alternative than cars. On paper, Polish Transport Policy clearly highlights increasing transport problems caused by traffic congestion, and that one of the objectives for municipal transport is find and utilize environmentally friendly alternatives to private cars (Kołoś and Taczanowski 2016). However, in reality the authors warn “Poland provides a good example of the lack of coherence between transport policy and practice. Despite the official transport policy guidelines to promote public transport the actual massive investments in road infrastructure promote rather individual than public transport” (Kołoś and Taczanowski 2016). Taylor (1998) has also critiqued overall Polish transport policy for supporting private cars rather than efficient and public transport. They will still make road investments rather than support municipal transport projects (Judge 2000). Indeed, after accession to the EU, Poland experienced a decade of unprecedented growth for motorways and highways, resulting in its threefold increase shown in Figure 5. Rosik et al. (2015) therefore characterize Poland as “big push” strategy founded on the notion that public investment in roads can help national economies overcome income disparities. As a result of these road investments, Poland has the lowest percentage of medium-sized cities served by LRRT and LRT systems, and it has a considerable number of relatively large cities with only bus networks (Kołoś and Taczanowski 2016).

A substantial increase in car use after 1989 has driven the process of urban sprawl, something that ironically leads to greater demand for cars and roads.

Figure 5: Polish national highway road network

In this context, the PRT offers a clean, efficient substitute. As MISTER (2008) notes, at least \$100 billion is lost every year in traffic jams. The PRT by contrast does not need roads, it has no tires (so less friction), it does not directly use fossil fuels (being powered by electricity), and it has energy recovery via braking. The PRT uses lightweight pods and guideways made from energy-efficient materials, and its reliance on external power displaces the need for “heavy, un-ecological, cumbersome batteries” (MISTER 2008: 21). As MISTER (2008: 22) states, within this frame, the PRT “is the answer for every city in the world with traffic jams and transportation problems”.

5.4 Symbolic-societal frames: harbingers of investment and economic development

The final sets of frames emphasize the grander symbolic dimensions to both projects, including a magnet for investment (DLR) and projecting an image of modernism (PRT).

DLR as harbinger of economic revitalization

The symbolic-societal frame of the DLR involves a mosaic of interconnected and mutually supportive narratives. Before the DLR, rapid economic decline throughout the docks and an almost complete loss of local manufacturing meant that by the early 1980s, almost half (40%) of Docklands land lay derelict in an area bordering the City of London (Church 1990). In 1983, the LDDC articulated “the severe problems in Docklands, of long journey times on both roads and public transport, and its reputation for isolation from known and important routes” and “current and forecast roads congestion problems” (quoted in Church 1990). The DLR was thus seen as a large part of revitalization of the Docklands area, a necessary node connecting the Dockland with the City and cementing strong links with the real estate market, and a mechanism for improving the image of Docklands in the eyes of potential investors and new residents.

A core justification for the DLR was to change the reputation and the image of Docklands. Carmona (2009) clarifies that the successful regeneration of the entire Docklands area depended on transport. However, there were no passenger railway services to the largest of the areas nearest to central London, the Isle of Dogs. Mainline railway lines into the eastern London termini skirted its north. The lower part of the Isle is (still) only road accessible by two bridges over the old dock entrances. It was proposed to build a conventional Underground railway line into the Isle of Dogs, but Margaret Thatcher refused to agree to that project because of its cost and because assessments suggested the DLR would be more affordable. Church (1988) underscores that when it was proposed, the DLR was the centerpiece of industrial development for the entire region, writing that it was a

“critical piece of development infrastructure that gave further investment credibility to the physical opportunities of Docklands”.

In commercial terms, under this frame the early years of the LDDC’s tenure were particularly successful. By 1987, 400 companies announced they would take advantage of the tax benefits and relocate to the Docklands. This rush of interest resulted in a land rush and property boom, seeing prices for property jump from almost nothing to more than £1.5 million an acre, coupled with the largest private housing and office building program ever seen in the UK (Carmona 2009). The DLR suggested that the Docklands area as a whole “had arrived”. As Church (1992) wrote:

Nearly all the transport improvements in Docklands have an additional motive of promoting the public image of Docklands. High-profile advertising and marketing have been used to portray Docklands as a unique area of wealth creation and enterprise and as an attractive place to live and work (Church 1992).

Similarly, Grant (1990) called DLR a central driver “in the phenomenal growth in demand for development in the Isle of Dogs and Leamouth”. Ward (1986) described it as the “critical piece of development infrastructure that gave further investment credibility to the physical opportunities of Docklands”. More recently, the DLR has been credited with “unlocking” and “transforming” the docklands and east London (Knowles and Ferbrache 2014). Because of its connections to broader economic development, the DLR has been named “the regeneration railway” (Steer Davies Gleave 2005). Stephen and Price (2017) concur “the DLR is at the heart of developments in east London. It plays a key role in the ongoing regeneration of the area, which is contributing to the continuing increase in residential and commercial populations”.

PRT as indigenous Polish economic modernism

In Poland, the symbolic-societal frame centered on projecting Opole as a modern, progressive city. In Poland, it was hoped that LRRT systems such as the PRT “could also be a vital factor of

economic development and of changing the city image” (Kołoś and Taczanowski 2016). More specifically, the PRT was designed to both serve as an active mobility and transport system *and* build up Opole city’s international reputation. MISTER (2008: 2) adds that a central reason for investing in the PRT is to “beautify” the city of Opole, “just as modern architecture does”. Ferbrache and Knowles (2017) note more generally a pattern of light rail systems such as the PRT being sold because they reshape cities to be modern, make cityscapes “softer”, and attain a “mythical allure”.

There is a Polish cultural element to this frame as well, given that Polish inventors designed the PRT indigenously. This dimension of the frame acknowledges that Poland can chart its own course for transport innovations; it does not need to rely on European Union directives. Taylor and Ciechański (2006) note since 1989, Poland has slowly resisted broader EU pressures pushing the deregulation of transport (hence the strong role of monopolies articulated above, in section 5.2), and most especially rail transport.

PRT as an enduring symbol of failed transport planning

This final symbolic-societal frame is the direct opposite of the economic modernism frame. It sees the PRT as the latest failed effort in a long historical line of unsuccessful PRT projects. Despite all of the hype surrounding PRT potential, and the recent wave of optimism in the past decade, only five completed PRT systems actually exist in the world: Morgantown West Virginia (1999), Rotterdam in the Netherlands (1999), Masdar City in Abu Dhabi (2010), Heathrow Airport in London (2011), and Suncheon Bay in South Korea (2014) (Jaffe 2014).

As Vuchic (1996) wrote and predicted, although the PRT concept has a compelling vision of capturing the pluses of private cars with the pluses of high efficiency mass transit with none of the minuses, in reality it represents a mutually incompatible hybrid of these two types of transport. As a result, PRT cars are often too small for users, and the guideways and stations too complicated for

planners and designers. Vuchic (1996: 35) concludes that “the PRT concept is thus a totally unrealistic ‘Buck Rogers’ concept for which there are no applications where it would be operated efficiently and economically.” For every successful case of a PRT system, the articulators of this frame note, there are many more failed and cancelled attempts ranging from the infamous Aramis PRT system proposed for Paris, France (Latour 1996) to the “PRT 2000” system invested in by Raytheon for the Chicago Regional Transport Authority in the United States (Vuchic 1996; 2007). A case in point is the Aramis project, which was cancelled after it was unable to counter the potential scenario that women driving these automated vehicles would be vulnerable to attacks from unsavory individuals in the same car, essentially becoming “rape wagons” (Latour, 1996: 21).

6. Conclusion

In sum, LRRT projects (and the broader system supporting their innovation and development) fulfill complex, and dynamically evolving roles. The DLR is not only a vital part of meeting (functional) demand for mobility, it can be framed as innovative and exciting to ride, a legitimization of a conservative approach to project development, a social injustice (to some), an environmentally friendly alternative to cars, and a magnet for global investment into the greater Docklands area. Similarly, although not yet fully operational, the PRT can be framed as not only a reliable and safe mode of public transit, but also a technical marvel, a monopoly breaking symbol, a clean and sustainable form of mobility, a reflection of progressive Polish innovation, modernity, and entrepreneurship, or, conversely, the latest attempt to push a failed and doomed idea of a PRT concept whose utility may have expired many years ago. The complexity of frames associated with LRRT projects reminds us that they not only mark the physical landscape but the mind. Perhaps more salient, such frames have been and continue to be adapted and contested across social groups and contexts. We see not only project developers or sponsors embroiled in frames, but also investors, policymakers, regulators, users,

and even entire governments and institutions. We see not only positive frames about innovation, excitement, and economic growth, but negative frames about injustice, cost overruns, and failure.

Consequently, frames for LRRT blend together private, societal, functional and symbolic dimensions. Some influence and relate to choices around the location, technological design and procurement process, espousing beliefs about the superiority of the private sector in delivering infrastructure projects, or the desirability of restructuring the economy around financial services. Other framing categories are more functional or rational, for example those that discuss the impacts on reduced car journeys, or on increased house prices, which can be stated independently of the psychology or world-view of any individual or group. Frames thus blend together evidence of impacts as well as perceptions.

Some frames, perhaps paradoxically, also contradict—frames emphasizing traditional, safe, or cheap transport attempt to situate the DLR or PRT as a simple alternate to conventional cars; this contrasts with frames underscoring the radical or innovative nature of the DLR or PRT, or that some (such as the PRT) are destined to fail. Similarly, frames presenting LRRT systems as forerunners of innovation, growth, and property are juxtaposed with narratives portraying them as insults to equality, egalitarianism, and social justice. Moreover, the frame of the PRT acting against the state owned monopoly structure in the Polish transport system contrasts with that of the PRT as an indigenous form of Polish innovation arising against the deregulation agenda coming from the EU. To use language from public policy or economics, such competing frames underscore that large infrastructure projects can have (or are perceived to have) multiple co-benefits, as well as trade-offs or dis-benefits.

As such, our investigation of frames raises questions for future research. To what extent to the functional or private features of frames give rise to symbolic or societal features, and vice versa? Are environmental factors such as climate change and reduced pollution the main drivers in some of these

frames, or are other factors significant, including political factors? If LRRT systems do have frames representing multiple benefits compared to other transport infrastructures, why have they not been replicated more widely? Could the frames attached to the DLR and PRT be more generally replicated and relevant in other cities adopting LRRT – if so how might institutional arrangements or other contextual conditions vary? Lastly, what are the relative roles of actors (state and private sector) in both creating and propagating frames?

Given the diversity of frames attached to our two LRRT systems, we should expect the domain of sustainable mobility transitions overall to remain a site of competing interpretations, if not contestation among frames. As a result, consensus on future mobility options should neither be expected nor sought. Put another way, no “master frame” may exist. Such underlying interpretive tensions, because they are about identity and society as well as technology or functionality, will likely remain with us even if our desire for vehicles and the types, nature, and delivery of mobility alters.

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