AN OVERVIEW OF AERIAL ROPEWAY TRANSIT AND ITS POTENTIAL IN URBAN ENVIRONMENTS

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Abstract

Mass transit systems present cities with significant potential advantages for economic, social, and environmental improvement (Lane 2008). However, geographical and topographical barriers and infrastructure costs may not permit the implementation of conventional public transportation systems such as light rail and buses (Pojani and Stead 2015). In these instances, city planners may look at unconventional modes of transportation to serve the needs of the residents. Aerial cable systems or urban gondolas, a type of aerial transportation mode in which passengers are transported in a cabin that is suspended and pulled by cables, is one of the solutions to such cases. The gondola lines are cheaper than light rail, can navigate more topographically challenging terrains than buses, and could offer an efficient solution as part of a policy of reducing pollution and greenhouse gas emissions. Using aerial ropeways in urban environments has gained more attention worldwide, and cities such as Medellin and Caracas have incorporated gondolas and aerial tramways into their public transport networks creating effective urban transport solutions (Alshalalfah, Shalaby, and Dale 2014). This paper attempts to shed some light on aerial ropeways technology from an urban planning perspective by presenting experiences with this technology and including the reasons for building these systems and their service and operational characteristics as well as other case-specific information. The paper concludes with an assessment of experiences with these systems including their benefits and limitations.

1 Introduction

'Cable-propelled transit' (CPT), in particular detachable aerial ropeways are widely employed as transportation systems in alpine areas. In recent years, these transport systems have also been increasingly used in urban areas and are no longer a niche public transportation technology (Hoffmann 2006, Alshalalfah, Shalaby, and Dale 2014). Cable cars systems compete with performance characteristics of other more common urban transport technologies and have the potential to enhance the existing transport provision in cities (O'Connor and Dale 2011). While many applications can be found as transportation systems in airport facilities, and to provide access to tourist attractions, several metropolitan areas have even incorporated gondolas and aerial tramways into their public transport networks. This paper focuses on aerial ropeway systems that operate as a mass transit service (similar to buses, BRT, LRT, etc.) and are part of the public transit systems in their respective cities. Therefore, the analysis and case studies presented in the paper concern systems that are used as a public transit service.

2 Background

A ropeway is an eco-friendly type of transportation mode in which passengers and shipment are transported in cabins that are propelled by steel cables. The principle of the cable-drawn transport scheme is not a new concept and has been applied mostly in terrain-challenged recreational contexts to transport skiers and tourists to mountain resorts and leisure parks. Technology and operational concepts, however, have evolved overtime to make them a reasonable and attractive alternative for mainstream urban public transport where conventional transit service was deemed very difficult or infeasible to implement (Bergerhoff and Perschon 2013, Alshalalfah, Shalaby, and Dale 2014). Recent systems classified according to the type of track (carrier) used (Hoffmann 2006). Top supported systems, also known as aerial cable systems, are supported from above via a cable (which may or may not be the same cable that propels the cabins — this varies by technology). Bottom supported systems are supported by tracks or rails underneath, yet are still propelled by a cable (The gondola project 2016). There are two types of aerial ropeways: the ″aerial tramway″ (telepherique) with two large cabins permanently attached to each leg of the pulling cable - the cable turns in one direction and stops when the reaching the stations; it then turns to the other direction; and the ″gondolas″ (telecabines), with a constantly revolving unidirectional pulling cable, to which smaller gondolas are attached and detached when entering and travelling through a station (Bergerhoff and Perschon 2013). The industry has made significant advances in the performance and capabilities of the technology, including the tricable configuration, faster line speeds and standardized intermediate and turning stations. Monocable technology is a term is used when a single cable is used to pull and support the cars (examples: Medellín in Colombia and Caracas in Venezuela). This type of technology means using small cars (generally fewer than 16 places) and limiting the distances between pylons (maximal distance: 600 to 800 metres). Bicable or tricable technology terms are used when one cable is used to pull the cars whilst one or two others support their weight (example: Coblenz in Germany). This type of system allows longer distances between pylons (up to several kilometres) and larger cars. Both monocable and bicable aerial ropeways offer several advantages when compared to traditional mass transit modes: high safety, high carrying capacity, long routes can be implemented (up to approx. 6 km/section), continuous passenger flows thanks to the constant movement, low space requirement along the route, no overlap with other forms of transportation (Hoffmann 2006, Alshalalfah, Shalaby, and Dale 2014) . Further advantages of the bicable and tricable aerial ropeway are that very long rope spans are feasible (up to approx. 1,500 m), and high wind stability.

Ropeways are extremely adaptable to the terrain and represent an optimal transport solution for challenging topographical landscapes such as hilly terrains (Alshalalfah, Shalaby, and Dale 2014). However, even on flat land, ropeways have the capacity to overcome many other types of natural and manmade obstacles, for instance rivers, lagoons and estuaries, harbours, railways and motorways. Depending on the possibility to place intermediate pylons, even city traffic be overcome without the construction of surface or underground infrastructures (Bergerhoff and Perschon 2013). In some areas, these cable car systems have emerged as an optimal way to connect informal settlements that got established over the past decades along steep slopes and hilly terrains and where public transport supply is largely underdeveloped. The major potential of aerial ropeway systems is seen in the significant increase in accessibility between these settlements and other locations within the urban fabric, supporting social inclusion and access to work and education opportunities (Dávila and Daste 2011, Bocarejo et al. 2014).

Additionally, integrating a cable car system into the existing transport infrastructure is relatively inexpensive compared to light rail or bus transit costs (see Figure 1) and it can be constructed quickly (London's Emirates Airline which crosses the River Thames, for example, was open for business 10 months after construction began).

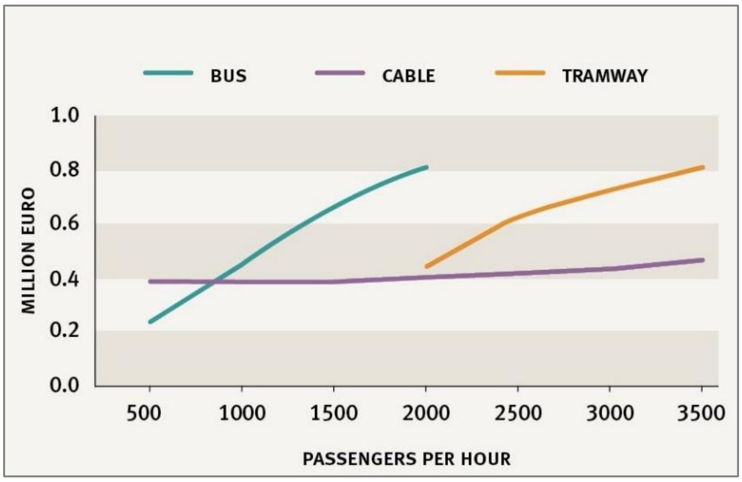

Figure 1: Indicative comparative cost based on operating cost of bus, tramway and ropeway in Grenoble, France (source: http://www.steerdaviesgleave.com/news-and-insights/cable-cars)

In terms of capacity, an aerial tramway service is comparable to that of a standard bus, while the gondola systems provide capacities comparable to small tramways (See Figure 2). The capacity of cable car systems is strictly limited by the maximal weight the cars and the cables can carry. Cable supports and other civil engineering components are sized for a predetermined weight; thus transport capacity cannot be adapted to demand.

More and more of these transit systems are appearing in cities all over the world (Bochum in Germany, Istanbul in Turkey and La Paz in Bolivia are only some of the latest examples). While these experiments are encouraging, it is worth considering the challenges of developing an aerial ropeway transportation system. One of the biggest biggest concern is that it cannot be modified or be difficult to integrate with existing transit systems because lines cannot branch off or turn. However, as shown in Medellin, carefully planned ropeway systems fully integrated with the public transit network, providing passengers with the ability to transfer seamlessly to local metro lines, can overcome this issue.

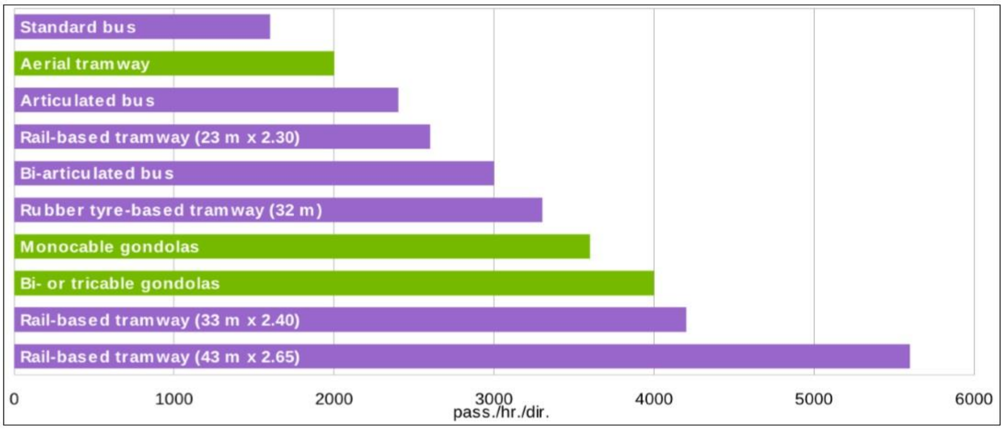

Figure 2: Capacity pphppd (passengers/hour) of typical urban transport systems (Bergerhoff and Perschon 2013)

Disadvantages of aerial ropeways systems include weather sensitivity, as safe operation may not be maintained in the event of extremely high winds (Hoffmann 2006). However, recent technology improvements have made gondolas and aerial tramways extremely safe and able to perform extremely well in windy conditions.

3 Urban aerial ropeway systems examples

3.1 Medellin, Colombia Metrocable

This new wave of urban aerial ropeways construction kicked off in Medellín, Colombia, which was the first city in the world to use the new system in an urban environment as a means of public transportation to to serve underprivileged hilltop neighborhoods. Medellín is presently home to three Metrocables, or aerial cable-car lines. Linea J and Linea K are both urban commuter lines that link directly to the city's rail system. Linea L connects residents to Parque Arvi, a large park located on the outskirts of town. Construction of the new system, the Metrocable Medellín, was completed in 2004. Soon, the idea caught on across Latin America, and cable cars began hauling passengers in major cities such as Caracas, Manizales, Rio de Janeiro, and most recently La Paz, Bolivia.

Figure 3: Aerial ropeway in Medellin, Colombia (Source: Getty Image).

The first line (Linea K) opened in 2004 and is considered the first fully integrated urban aerial cable car system in the world. Linea K soon started running at full capacity and is widely perceived as a success, thus prompting other cities in Colombia and Latin America, such as Rio de Janeiro and Caracas, to launch similar systems (Dávila and Daste 2011). Both Metrocable lines J and K connect neighborhoods located in the mountain foothills that surround the city. While Linea K is located in a well-established and populous area, Linea J extends into a barrio (neighbourhood) that is currently experiencing rapid growth. Both lines have had positive impacts on their surrounding area improving accessibility to outside destinations and decreasing commuting time.

Figure 4: Medellín's Metro system (source: https://www.metrodemedellin.gov.co).

The Metrocable was designed as part of an integrated urban project (Proyecto Urbano Integrado, PUI), and led by the local government-owned mass transit authority (Empresa Transporte Massivo, EMTVA). The project was supplemented by the construction and upgrading of community facilities and public spaces and efforts to involve residents in the planning and implementation. This approach is aligned with wider urban-planning goals of improving the living conditions for residents within informal settlements and demonstrating that after decades of neglect, city planning and politics finally were addressing the problems of these communities (Dávila and Daste 2011).

Table 1: Metrocable lines: basic information (source: https://www.metrodemedellin.gov.co/).

	Line K	Line J	Line L
Launch date	2004	2008	2010
Length	2,072 m	2,782 m	4,469 m
Commercial speed	5 m/s	5 m/s	6 m/s
Hourly capacity	3,000 pphppd	3,000 pphppd	1,200 pphppd
Total cost	US$ 24 million	US$ 47 million	US$ 21 million
Source of finance	Municipality:55% Metro: 45%	Municipality:73% Metro: 27%	Municipality:38% Metro: 34% Provincial government: 17% Ministry of Transport: 9% Other: 2%
Fare integrated with metro	Yes	Yes	No

3.2 Caracas, Venezuela

The first aerial ropeway Caracas dates back to 1952, although the cable car transportation system was decommissioned in the late 1970’s and re-built (with extension) by 2010 to a length of 3.5km, serviced by 70 gondolas, following the “Metrocable” of Medellin. As in Medellín, the aerial ropeway systems in Caracas was planned as feeders to the existing rail based high capacity public transport line connecting hillside neighborhoods to the remaining urban fabric. The first metrocable line in Caracas was planned to connect the community of San Agustin to Central Park (Parque Central) Station, where it is linked to the subway system (Bergerhoff and Perschon 2013, Alshalalfah, Shalaby, and Dale 2014). Like other barrios with a history of crime and poverty in the Venezuelan capital, San Agustin is one of the poorest and socially most challenged neighborhoods, running steeply and dangerously up the mountainside, making transport by vehicle difficult

Figure 6: View of Hornos de Cal station, Caracas (source: http://www.moma.org/interactives/exhibitions/2010/smallscalebigchange/projects/metro_cable)

and often impossible. Urban Think Tank, and architectural firm, made a proposal to the city to build a cable car system linking San Augustin with Caracas’s public transit system. The plan, which was the result of site surveys, community workshops, and other on-the-ground fieldwork by the architects, is based on the cable car system but calls for “plug-in” buildings—structures attached to each station housing cultural and recreational programs—as well as other, smaller-scale interventions close by. As a result, unlike the Medellin systems, Caracas Metrocable features enormous stations that included social facilities such as gymnasiums, police stations, community centres and markets. The Caracas Metrocable is also the first in the world to feature extreme 90 degree turning radii at stations (The gondola project 2016).

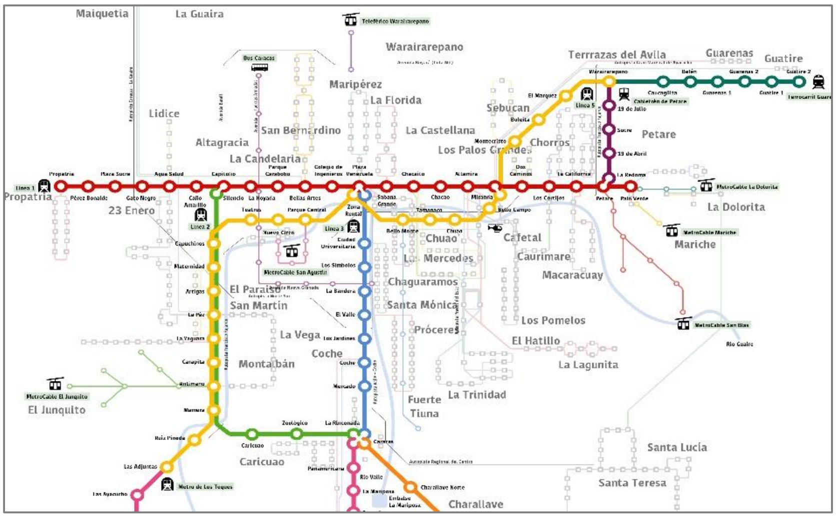

Figure 5: Caracas map of public transport (partial) (source: https://commons.wikimedia.org/)

4 Conclusions

The introduction of new transit modes into the array of urban transit systems has been an area of great interest to transit agencies, inventors, manufacturers and even governments. The need for transit modes for specific conditions has led to the introduction of entirely new and unconventional modes such as aerial ropeway systems. Technical innovation has made aerial ropeway systems a comfortable, high capacity public transport system, which can create direct links without massive infrastructure. As seen in Medellín and Caracas, what makes cable car schemes work in an urban context is their holistic approach with strong emphases of community development and their integration with the rest of the transport network, particularly – but not exclusively – public transport services. In both these cities, the aerial ropeway system was not planned alone but as part of a bigger urban regeneration project aimed at improving quality of life in the most deprived and underserved areas of the city.

It is worth mentioning that despite most of the existing aerial ropeway applications are in topographically challenging regions, such as mountain terrain, the technology could also be considered as a viable option for applications in space-constrained urban areas such as downtown areas, supplementing the set of technological tools available to transit planners and decision makers. Reduction of road congestion, parking problems, noise and air pollution (gondolas do not have motors and run on electricity) are few of the most relevant reasons which may spur further development of aerial ropeway transport systems in urban areas. Aerial ropeway systems market has the potential to become the dominant market for the cable industry in the future as cities worldwide are beginning to realize the potential of urban gondolas as part of a solution to their transportation needs. Especially in cities in developing countries without rail or BRT systems, ropeways can change and improve urban mobility and help achieve sustainability and equity goals. This presents researchers and scholars with the opportunity to start developing more case studies and performance analyses that may support further diffusion of urban aerial ropeway transit systems.

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