



# FROM MOUNTAINS TO CITIES

Scientific Insights into Cable Cars as Urban Transport Systems

# DES MONTAGNES AUX VILLES

Perspectives scientifiques sur les téléphériques en tant que systèmes de transport urbain

Mountain Planet / Planning for 3CS | Grenoble, 22.4.2026

**Dr. Stephan Tischler** / University of Innsbruck

~ **25,000** ropeways  
~ **300** urban cable car systems  
currently in operation or advanced development





Source: BMW Group, 2018

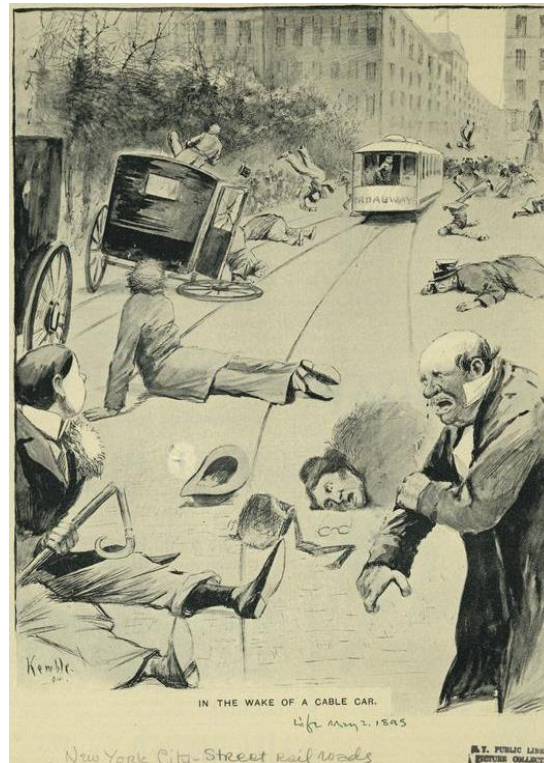
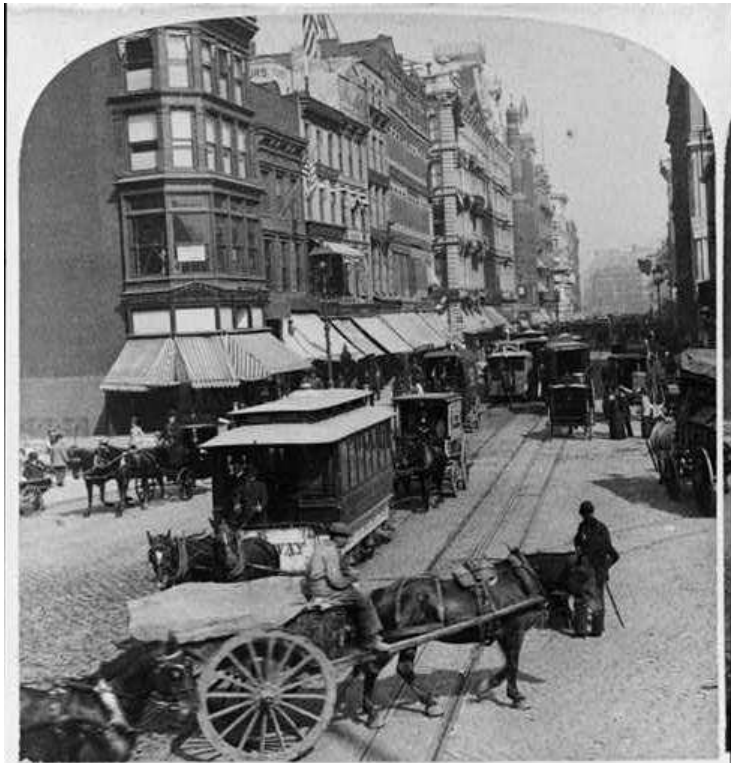
# Scientific Insights into Cable Cars as Urban Transport Systems



- I. Introduction
- II. Technical Foundations & Engineering Physics
- III. Environmental Science & Sustainability
- IV. The "Social Urbanism" Lens
- V. Urban Planning & Network Science
- VI. Conclusion

# I. Introduction: The Urban Ascent

## Ground Cable Cars (1873–1920)



Courtesy: The New York Public Library (NYPL)

# I. Introduction: The Urban Ascent

## Historical Context

1910

1960

2010



*Kohlerer Ropeway, Bolzano (Italy)  
in operation since 1908*



*Chairlift, Vienna (Austria), 1964*



*Chairlift Skiresorts, 2018*



*Urban Ropeway, Caracas (Venezuela), 2010*

# Aerial Ropeway Transit (ART)

# I. Introduction

## user expectations

1. Reduce travel time
2. Reduce pollution
3. Improve in-vehicle security
4. Improve comfort
5. Improve security at the station
6. ...

source: Guzman, L. et. a. (2023): User expectations and perceptions towards new public transport infrastructure: evaluating a cable car in Bogotá, <https://doi.org/10.1007/s11116-021-10260-x>

**Table 2** Aggregate model estimates

Attribute	Expectation			
	Estimate	t-test	Pi	Rank
A1. Reduce travel time	4.725	10.41	55%	1
A2. Improve comfort	2.479	6.83	6%	4
A3. Improve reliability in waiting time	1.773	4.92	3%	8
A4. Improve in-vehicle security	2.596	7.12	7%	3
A5. Improve security at the station	2.027	5.66	4%	5
A6. Improve road safety	1.799	5.02	3%	6
A7. Increase the number of places I can accede	1.043	2.80	1%	11
A8. Increase the number of schedules I can travel	0.000	–	0%	13
A9. Improve the frequency of the service	1.562	4.34	2%	9
A10. Reduce the fare	1.453	3.99	2%	10
A11. Reduce pollution	3.213	8.24	12%	2
A12. Improve reliability in arrival time	1.787	4.97	3%	7
A13. Improve the neighborhood aesthetic	– 0.031	– 0.07	0%	14
A14. Improve the quality of life	– 1.033	– 1.84	0%	15
A15. Nothing	0.274	0.66	1%	12
A16. Other	–	–	–	–
Panel (std. dev.)	1.378	6.70	–	–
Log-Likelihood		– 2133.0		
Adjusted Rho2		0.169		

## II. Technical Foundations & Engineering Physics

- **Mechanics of Motion**  
The science of the detachable grip and continuous loop systems
- **Capacity Metrics**
  - Analyzing PPHPD (Passengers Per Hour Per Direction)
  - Comparison Table
- **Topographic Advantage**  
The physics of "Linear Gradient" vs. "Vertical Gain"

# II. Technical Foundations & Engineering Physics

## Comparison Table

	Transport Mode		Investment Cost	Line Capacity	Vehicle Capacity	Operational Speed	Cars / TU
			(\$Million/km)	(PPHPD)	(Passenger)	(km/h)	
Conventional Transit Systems	Street Transit	Bus	0.5-0.6	3,000-6,000	80-125	15-25	1
		Tram	5-10	10,000-20,000	100-300	12-20	1-3
	Semirapid Transit	BRT	5-40	6,000-24,000	80-180	20-40	1
		LRT	10-50	10,000-24,000	100-720	20-45	1-4
	Rapid Transit	Metro	40-100	40,000-70,000	720-2,500	25-80	4-10
		Regional	50-120	25,000-40,000	150-1,800	40-80	1-10
ART Transit Systems	Aerial Tram		15-25	500-2,800	20-200	43.2 Max.	1
	Dual-haul		20-25	2,000 Max.	100 Max.	27 Max.	1
	MDG		5-10	3,600 Max.	4-15	21.6 Max.	1
	BDG		10-20	4,000 Max.	4-17	25.2 Max.	1
	TDG		15-25	7,000 Max.	35 Max.	30.6 Max.	1

**Table 1:** Service Characteristics of ART and Conventional Public Transit Systems.

pphpd: passengers per hour per direction

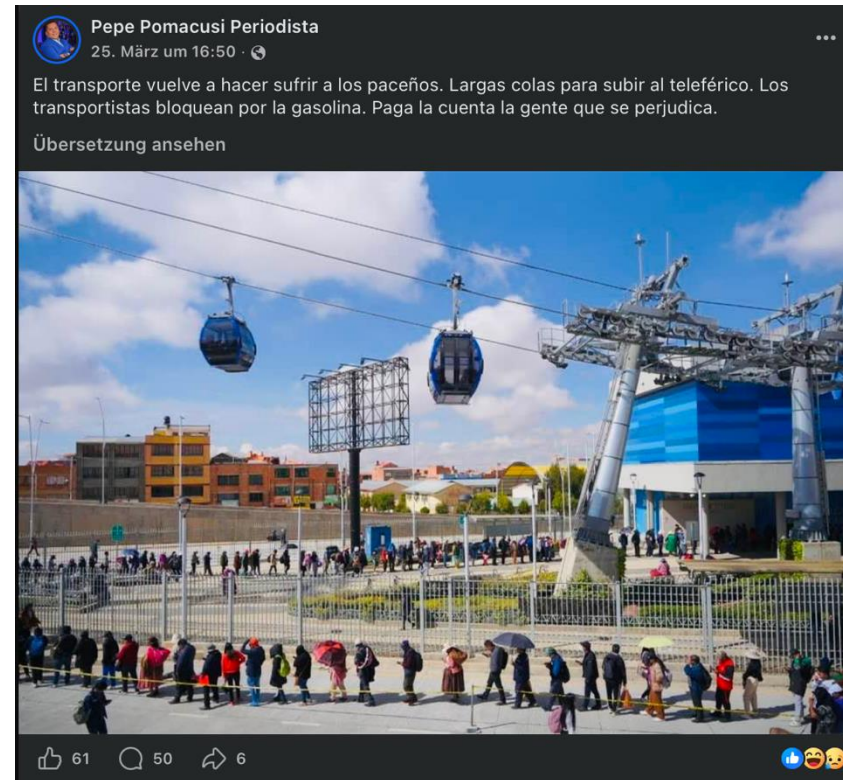
Source: Author

Data source: Alshalalfah, et al. 2012; Winter, 2016; CUP, 2016

## II. Technical Foundations & Engineering Physics

Integration of urban aerial cable cars into public transit

capacity limits due to passenger queuing at station



# II. Technical Foundations & Engineering Physics

Integration of urban aerial cable cars into public transit

## capacity limits due to passenger queuing at station

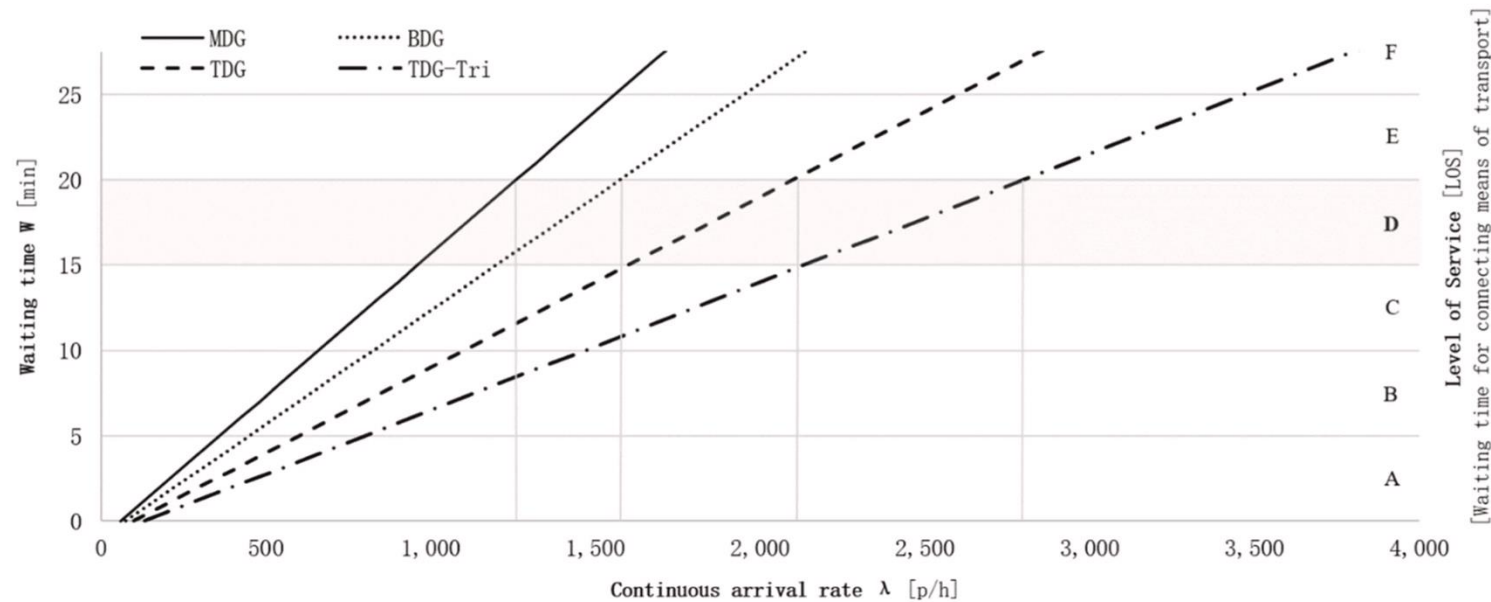


Fig. 5. Use case 2 - continuous arrivals for arrival rate  $\lambda$ .

source: Felsser, M. et. a. (2024): Integration of urban aerial cable cars into public transit: Operational capacity limits due to passenger queuing at stations, <https://doi.org/10.1016/j.jpuptr.2024.100094>

# II. Technical Foundations & Engineering Physics

## Integration of urban aerial cable cars into public transit

### capacity limits due to passenger queuing at station

**Table 4**

Minimum headways of arriving vehicles combined with cable cars.

Technology type, e.g.	Bus [min]	Art-Bus [min]	BRT [min]	Tram [min]	Subway [min]	C-Rail [min]
Monocable detachable gondola (MDG)	1.0	2.0	3.0	7.5	15.0	20.0
Bicable detachable gondola (BDG)	1.0	1.0	3.0	5.0	10.0	15.0
Tricable detachable gondola (TDG)	1.0	1.0	3.0	5.0	7.5	10.0
TDG as Tri-Line (TDG-Tri)	1.0	1.0	2.0	3.0	5.0	7.5

**Table 5**

Space requirement for queuing areas.

Technology type, e.g.	Queuing area derived from arrival rates and waiting time (LOS D) [m <sup>2</sup> ]						
	Bus	Art-Bus	BRT	Tram	Subway	C-Rail	Cont. Arrivals
Monocable detachable gondola (MDG)	≥ 360	≥ 12	≥ 160	≥ 300	≥ 250	≥ 340	≥ 380
Bicable detachable gondola (BDG)	≥ 90	≥ 450	≥ 40	≥ 540	≥ 470	≥ 410	≥ 470
Tricable detachable gondola (TDG)	≈ 0	≈ 0	≥ 30	≥ 120	≥ 660	≥ 630	≥ 630
TDG (Tri-Line)	≈ 0	≈ 0	≥ 20	≥ 680	≥ 1000	≥ 880	≥ 840

source: Felsser, M. et. a. (2024): Integration of urban aerial cable cars into public transit: Operational capacity limits due to passenger queuing at stations, <https://doi.org/10.1016/j.jpubr.2024.100094>

## III. Environmental Science & Sustainability

- **Energy Efficiency Profile:**
  - comparison of kWh per passenger-kilometer
  - The "Constant Motion" advantage
- **Land Use Footprint**

Analyzing the "Point-to-Point" nature of towers vs. the continuous "Surface Scarring" of roads and tracks.
- **Acoustic Ecology**

Scientific measurements of noise pollution in transit-adjacent neighborhoods.

# III. Environmental Science & Sustainability

## environmental impact / life cycle assessment

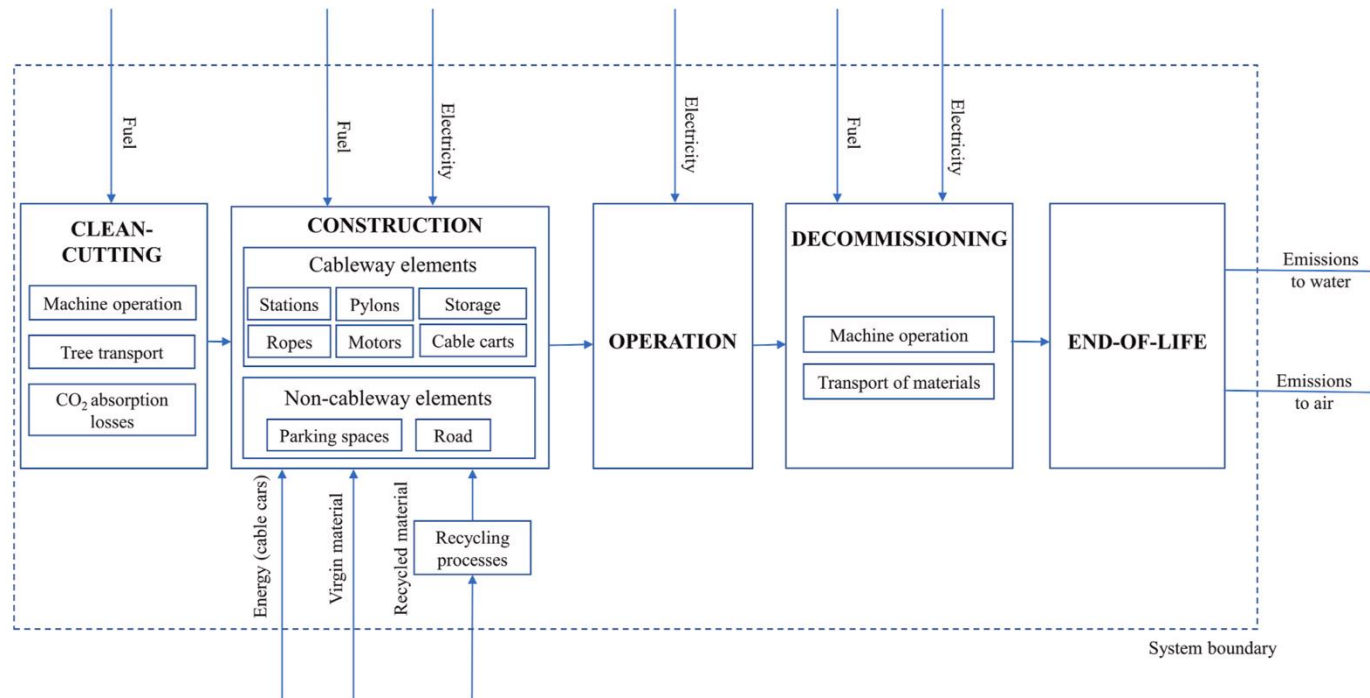


Fig. 1. Schematic representation of the system boundary.

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World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

Impact of aerial cable car in low-income area in Medellín, Colombia  
Mihoko Matsuyuki<sup>a,\*</sup>, Sarika Okami<sup>b</sup>, Fumihiko Nakamura<sup>a</sup>, Iván Sarmiento-Ordosgoitia<sup>c</sup>

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<sup>c</sup>Faculty of Mines, Universidad Nacional de Colombia, CI 80 8 65-223, Medellín, Colombia

**Abstract**

In this study, we examine the effect of *Metrocable* cable-car projects and their socio-economic and spatial scope in *Comuna 1* by two questionnaire surveys administered to residents and *Metrocable* passengers. We found that *Metrocable* commuters are saving time and money. Women in the low socio-economic class who live near a *Metrocable* station and work at safe *Comunas* with a train station likely use *Metrocable* for commuting. In addition, the installation of *Metrocable* in 2004 facilitated vocational job changes, which have led to higher incomes. However, it must be noted that the lowest income and education classes rarely use *Metrocable* for commuting. Besides, our research revealed *Metrocable* has not influenced the amount of crime in the neighborhood area in the last decade, which was perceived as an effect of passengers viewing crime from the air, but it has increased the passengers' senses of pride about their neighborhood. As a part of the integrated urban project (PIU), the CEDEZO, and *España* Library are mainly used by women with higher educational background.

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Peer-review under responsibility of the scientific committee of the World Conference on Transport Research – WCTR 2019

**Keywords:** Aerial cable-car, *Metrocable*, low-income area, socio-economic impact, spatial scope, local social development, integrated urban project (PIU)

**1. Introduction**

**1.1. Background and objectives**

The relationship between mobility and social exclusion has been an important issue within transport engineering and policy (Ohnmacht et al., 2009). *Metrocable* in Medellín, Colombia is an aerial cable car system running in a low-income neighborhood that connects the hillside area to the main train system running through the river valley, where the city center is located. The first *Metrocable* line launched in 2004 did not have the explicit objective of poverty

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10.1016/j.trpro.2020.08.150

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## environmental impact / life cycle assessment

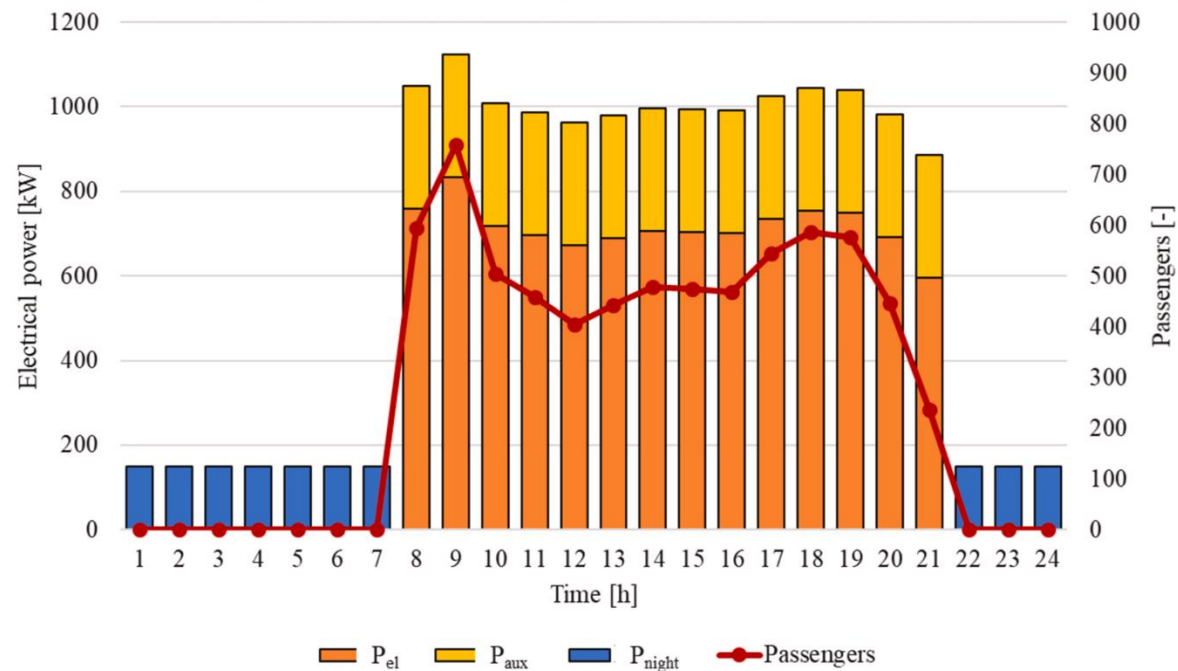


Fig. 3. Hourly electrical power and passengers' profiles for a total daily passengers' value equal to 50% of the potential cableway user.

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

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## IV. The "Social Urbanism" Lens

- data from Medellín & La Paz
  - Economic Mobility  
correlation between cable car access and employment rates in peripheral districts
  - Crime & Safety:  
Research on the "Passive Surveillance" effect
- The Gentrification Paradox
  - studies on property value increases
  - risk of displacing the very populations the system was built to serve

# IV. The "Social Urbanism" Lens

## The Medellín Miracle

**1991:** 381 murders per 100,000 people

- Key social factors: long-standing problems of inequality and exclusion
- investments in education, public infrastructure and public spaces

**2004:** cable car (Avodeco - Santo Domingo Savio)

- connects one of the most dangerous parts of the city's hillsides to its wealthy centre
- Cutting travel times from > 60min to average of 15min
- powerful symbolic value

**2015:** 20 murders per 100,00 people



## IV. The "Social Urbanism" Lens

### The Medellín Miracle

*„I used to say I'm going to Medellín, now I say I'm going to the city centre“*  
(local resident, Medellín)



Picture: Edgar Jiménez from Porto, Portugal - Metrocable - Línea J, CC BY-SA 2.0, <https://commons.wikimedia.org/w/index.php?curid=30792287>

# IV. The "Social Urbanism" Lens

## Research on the "Passive Surveillance" effect

- Elevated **Sightlines** → clear, unobstructed lines of sight over urban areas
- Constant **Movement**
- Natural **Supervision** → passengers act as passive observers
- **Active Edges** → public transit activity into previously isolated areas



## V. Urban Planning & Network Science

- **Intermodality**  
The science of "Transfer Friction" – how stations act as hubs for subways and buses
- **The Last-Mile Solution**  
Mathematical modeling of commuter time-savings in "vertical" cities
- **Visual and Privacy Impact**  
Psychological studies on "Perceived Privacy" for residents living beneath transit lines

# V. Urban Planning & Network Science

## Mathematical modeling of commuter time-savings

### La Paz–El Alto cable car system

- **travel time** is reduced by 22% on average when commutes are made by cable car instead of another transport mode
- **daily travel time** decreases by 9 min

*“No matter how short or long the commute, it takes less time when the cable car network is used.”*



# VI. Conclusion

## user expectations and perceptions

- Benefit expected as well as perceived: **travel time**
- **Comfort and in-vehicle security** are the benefits that the users perceived to be most improved compared to their expectations
- **reduction in pollution levels** is the attribute that lost the most ground

**Table 2** Aggregate model estimates

Attribute	Expectation				Perception			
	Estimate	t-test	Pi	Rank	Estimate	t-test	Pi	Rank
A1. Reduce travel time	4.725	10.41	55%	1	5.426	9.27	57%	1
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A6. Improve road safety	1.799	5.02	3%	6	1.662	3.33	1%	9
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A13. Improve the neighborhood aesthetic	– 0.031	– 0.07	0%	14	1.213	2.33	1%	10
A14. Improve the quality of life	– 1.033	– 1.84	0%	15	– 1.613	– 1.47	0%	16
A15. Nothing	0.274	0.66	1%	12	1.683	3.35	1%	8
A16. Other	–	–	–	–	– 0.227	– 0.33	0%	15
Panel (std. dev.)	1.378	6.70	–	–	0.757	2.72	–	–
Log-Likelihood		– 2133.0				– 1475.3		
Adjusted Rho2		0.169				0.342		

source: Guzman, L. et. a. (2023): User expectations and perceptions towards new public transport infrastructure: evaluating a cable car in Bogotá, <https://doi.org/10.1007/s11116-021-10260-x>

## VI. Conclusion

- significant shift of academic research into Aerial Ropeway Transit (ART) over the last two decades
- Studies cluster around four primary thematic “pillars”:
  - Socio-economic impact
  - Integration and connectivity
  - Technical performance and environmental footprint
  - Urban planning and public perception
- majority of analyzed systems in South America

In which areas could science assist in decision-making?



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