ETSAB: Urban Gondolas in Public Transit

Is this a Viable Option for Edmonton?

Recommendation

1. That Administration, in consultation with key stakeholders conduct a study to explore the high-level feasibility and benefits of building an urban gondola as an alternative or complementary solution to other transport options across and into the river valley that is fully-integrated into our public transit system, and the communities it would serve.

Executive Summary

Urban gondolas are highly versatile mass transit solutions that provide fast, reliable, safe, fully accessible and cost-effective transportation into even the most geographically challenging areas. As Edmonton grapples with how to increase transport capacity across our river valley and better connect Downtown and Old Strathcona, a gondola is uniquely well-suited to provide this capacity. ETSAB's research suggests this is a viable project that warrants further consideration and study.

Report

The purpose of this report is to provide objective information and research to City Council, ETS and administration on the viability and capabilities of urban gondolas in city transportation systems. In recent months there has been a lot of publicity and media attention on the topic of urban gondolas. This report aims to dispel some common misconceptions and provide facts and evidence to facilitate an informed debate. ETSAB conducted an extensive literature review and consulted with subject matter experts and urban gondola operators from around the world to inform the findings.

ETSAB considered a number of different routes and ultimately determined the best application of the technology that would deliver the most benefits on a City-wide level would be to connect Downtown and Old Strathcona, with an interim station in the Rossdale community.

The report also highlights some of the known limitations and contains information on relevant case studies and examples from around the world.

Some of the most compelling benefits and capabilities of urban gondola transportation include:

- High passenger capacity that rivals LRT. Gondolas can accommodate between 4,000 to 6,000 passengers per hour per direction depending on the design. One gondola system can transport the same number of people per hour as 2,000 cars or 100 buses.
- Alleviates traffic congestion by providing cost-effective grade separation.
- Fast and efficient: average system speeds are in-line with the average speeds traveled by conventional bus service and comparable to urban low-floor LRT speeds when factoring time stopped at stations.
- Extremely high reliability (>99%) and safety rating compared to other modes of transit.
- Fiscally-responsible: capital costs per kilometre are a fraction of what LRT and BRT would cost. Could be an attractive investment for private partnerships given that numerous systems ETSAB studied are revenue-positive.
- One of the most environmentally friendly modes of transit. (0.1 kWh/KM / passenger)
- Barrier-free accessible transit that easily accommodates mobility aids, strollers and bikes. Individual cabins slow or stop without impacting the overall system speed.
- It is a scalable solution where capacity can be increased with minimal incremental operating costs.
- Minimal wait times for passengers and easy integration with existing transit. Since it is a continuously moving system, there is no need to align timetables/schedules.
- Fast construction times. The prefabricated design means construction is often completed in under 12 months. This minimizes disruption to residents, businesses and commuters.
- Smallest footprint for a transportation project and would entail the least amount of development, construction and infrastructure in the river valley.

Alignment with City's 10-year Strategic Plan and Corporate Outcomes:

An urban gondola system connecting Downtown with Old Strathcona would yield many benefits for all Edmontonians and the City of Edmonton. The project aligns closely with the City of Edmonton's 10 year strategic goals and would improve performance on many of the corporate outcomes and targets set by Council.

- **Enhance the Use of Public Transit and Encourage Active Modes of Transportation**. An urban gondola will provide fast and efficient mass transit across one of Edmonton's most congested and high-traffic commuting corridors.
- **Ensuring Financial Sustainability**: An urban gondola system would be one of the most cost-effective methods of providing mass transit across the river valley. For a fraction of the cost of building a new bridge or refurbishing an existing one, an entire gondola system could be built and operational in significantly less time.

- **Transforming Edmonton's Urban Form**: A gondola system requires minimal land acquisition and would preserve the nature of the river valley by minimizing development impacts. It would offer transit-oriented development (TOD) opportunities and support high density, vibrant neighbourhoods.
- **Preserve and Sustain Edmonton's Environment**: A fast transportation option with exclusive right-of-way between Old Strathcona and Downtown would encourage more citizens to use public transit. Gondola systems are environmentally sustainable and utilize very little energy to transport large numbers of passengers.
- **Improves Liveability**: Improving connectivity between these two high-density walkable neighbourhoods will enhance liveability in both neighbourhoods by improving connectivity, safety and improving access to recreational activities.
- **Diversify Edmonton's Economy**: An urban gondola could be a significant draw for Edmonton's increasing number of overnight visitors and tourists.

Attachments

1. Report: Urban Gondolas in Public Transit - Is this a viable option for Edmonton?

Attachment 1

Urban Gondolas in Public Transit:
Is this a viable option for Edmonton?

A high-level study of the capabilities and benefits of aerial cable-propelled transit to enhance connectivity in Edmonton

Table of Contents

Urban Gondolas as Mass Transit Solutions

An urban gondola across Edmonton’s river valley would provide high capacity, efficient and cost-effective mass transit over one of Edmonton’s most challenging topographical areas.

Executive Summary

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- Smallest footprint for a transportation project and would entail the least amount of development, construction and infrastructure in the river valley.

For most people the word ‘gondola’ conjures up images of recreational ski lifts and novel tourist attractions - however the research demonstrates they can provide cost-effective mass transportation with many unique advantages and characteristics. The recent negative media attention on the subject has perpetuated several misconceptions and myths; ETSAB is hopeful this report will provide some statistics so the idea can be objectively considered. Although the project seems more of a ‘nice-to-have’, the research and evidence from other cities suggests it makes a lot of sense when done to solve certain transportation challenges - certainly enough to warrant further study and exploration.

While gondolas can and have been used in many urban, recreational and industrial contexts, ETSAB primarily studied the idea of an urban gondola to cross the river valley and connect downtown with Old Strathcona and the Whyte Ave area. Although a case could be made to look at other potential routes around our city, we felt this was the best and most optimal use of the technology given the high traffic and transit ridership volumes, the need to preserve the river valley and the exorbitantly high price it would cost for any alternative transportation solution to traverse the river valley.

There is ample rationale and evidence to suggest this would be an attractive investment for Edmonton to make into expanding our transportation network. Based on our research, urban gondolas scored highly in nearly all criteria we examined - from speed and capacity to financial viability and environmental impact. Gondola systems are relatively inexpensive and fast to construct, do not contribute to traffic congestion, are very safe, and have a minimal footprint and land acquisition needs. Inside they are luxurious, spacious and offer unparalleled views.

Also relevant to consider is the high ridership capacity to cost ratio that most gondolas systems can achieve. A 5,000 person per hour per direction gondola is the equivalent of 100 full size buses. Several of the gondola systems we examined are revenue positive, with fare revenue exceeding operating and maintenance costs. For less than the cost of refurbishing one bridge, or grade-separating LRT or BRT from only one or two intersections, an entire multi-station system could likely be built.

The following sections provide some background information on gondolas and make a case for why Downtown to Old Strathcona is an ideal route that capitalizes on many of the unique capabilities of gondolas. The report also highlights some known limitations of the technology, profiles some relevant systems from a North American context, provides some high level financial data as a point of comparison, and briefly touches on some lessons learned from other projects.

Scope and Purpose of the Report

The purpose of this report is to provide information and relevant research to City Council, ETS and administration that demonstrates the viability and capabilities of urban gondola transportation systems. ETSAB conducted research on a number of topics including:

- What type of transportation problems are most suitable for urban gondolas;
- What are the unique characteristics and benefits of urban gondola solutions;
- How do gondolas compare with other modes of transit, such as bus, BRT and LRT;
- What are the high-level capital, operating and maintenance costs of urban gondolas.

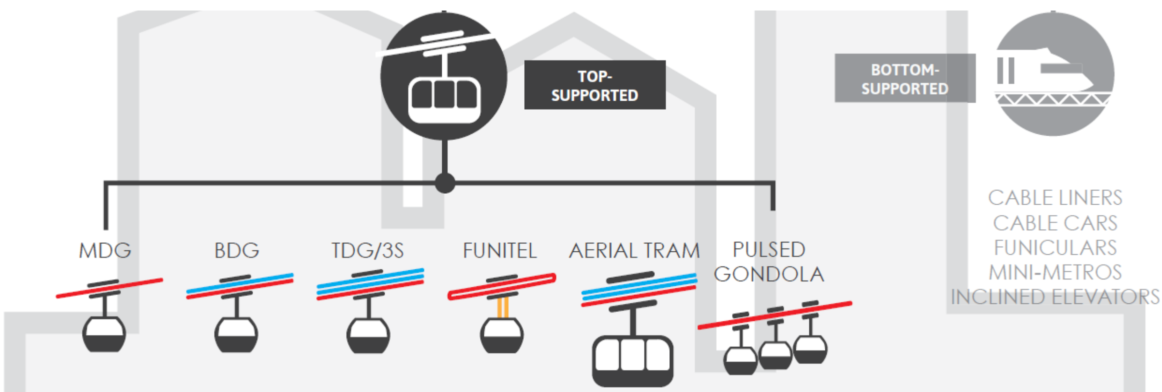
The research involved conducting interviews with representatives of other systems, obtaining information from recognized experts in the field, reviewing third party reports and reviewing a variety of news articles and other publications on the subject. One area we did not research or provide an opinion on was what type or design of urban gondola should be considered. There are many different configurations which are briefly introduced in the following section. ETSAB felt the project should be validated on a conceptual and feasibility level before engineers and technical experts determine the optimal design based on the City's requirements, the expected ridership, and other factors.

Background

What are Urban Gondolas?

During our research we encountered many different types of Cable Propelled Transit (CPT). All forms of CPT can broadly be subdivided into two categories - top-supported CPT and bottom-supported CPT. Examples of the bottom-supported CPT include Edmonton's new funicular and the iconic cable cars found in San Francisco.

In this report we use the term 'urban gondola" as a catch-all term for a top-supported cable propelled transit system. We used this term in the general sense for consistency but recognize that there are numerous distinct variations as shown in the diagram below. Each has unique characteristics, capabilities and costs. Our intent was to keep the discussion at a high level and use 'urban gondola' as a blanket term for top-supported CPT.



Source: Cable Car Confidential (2013)

Each type of top-supported CPT is characterized in the chart below:

	MDG	BDG	3S/TDG	FUNITEL	AERIAL TRAM	PULSED GONDOLA
Description	The monocable detachable grip gondola (MDG) is the most common aerial gondola technology available. It utilizes one cable for both support and propulsion.	The bicable detachable grip gondola (BDG) is similar to the MDG but with two cables - one cable for propulsion and one track cable for support.	The 3S/TDG gondola is currently the fastest and highest capacity gondola technology available. It has a detachable grip and three cables - two for support and one for propulsion.	The funitel is a detachable grip system that looks like an aerial tram but acts like a gondola. The system utilizes one dual loop cable to carry short-armed cabins.	The aerial tram is a large cabin, fixed grip system consisting of one or two vehicles. The traditional aerial tram has two vehicles fixed to the same cable loop, shuttling back and forth in tandem.	Pulsed gondolas are fixed grip systems that bunch MDG/BDG style cabins together into "pulses" (as opposed to spacing them out along the cable).
Maximum Speed (kph)	~22	~25	27+	~27	~45	~22
Maximum Capacity (pphpd)	Up to 4000	Up to 4000	Above 6000	4000-5000	Up to 2000	Up to 2000
Maximum Wind Speed Operation (kph)	Up to 70	Up to 70	100+	100+	80+	Up to 70
Capital Cost (relative to other CPT technologies)	Low	Low-medium	High	Medium-high	Medium-high	Low
Grip	Detachable	Detachable	Detachable	Detachable	Fixed	Fixed

Source: Cable Car Confidential (2013)

The concept of using ropeways is certainly not new and it is difficult to trace the exact origin of this transportation method. The advent of steel cables in 1834 gave rise to the first monocable and bicable patents in the mid-to-late 19th century.[1]

The 1923 Gothenburg cable car. Images: Gothenburg City Museum

Image Source: How We Get To Next [2]

The New York Roosevelt Island Tram was arguably the first modern *urban* example of cable propelled transit which opened in 1976. It underwent a full renovation in 2010 to improve efficiency and extend its life cycle by 30 years, reiterating its utility as a key mode of transit in Manhattan.

[1] Cable Car Confidential
[2] https://howwegettonext.com/cable-cars-are-changing-the-world-61f2b803c129

Why a Gondola in Edmonton?

Edmonton's river valley is undoubtedly the crown jewel of our capital city. From a transportation perspective, it is a difficult topography to traverse and creates a significant challenge in connecting Edmonton's communities to the North and South of the river. As Canada's largest urban park, it is incumbent on us to preserve this nature and minimize any development impact. An urban gondola would be the least invasive form of mass transit that could be built, and requires the least amount of land to be acquired and developed.

An urban gondola is the most practical way to provide transit across the river valley since:

- The wide expanse and steep slopes of the river valley make it difficult and costly for other modes of transit. Gondolas easily cross large barriers (mountains, rivers, railway tracks or highways) where a bridge cannot be built or is too costly to build.
- There are a limited number of bridges to travel north/south between downtown and Old Strathcona: the Walterdale bridge, James MacDonald bridge, High Level Bridge and the Low Level bridge. During peak traffic hours they are very congested and as our City grows congestion on our bridges will continue to increase.
- Even pedestrians and cyclists have complained about insufficient capacity to satisfy all the foot/cycle traffic. With over 4,000 cyclists and pedestrians per day, the High Level bridge is Edmonton's busiest cycling corridor. It is such a significant problem Mayor Iveson suggested a partial bike ban may be needed.[3] In 2016 we learned it may take at least five years before we look at widening the congested sidewalk"[4]

Vendor Landscape and Local Expertise

The cable car / gondola industry is primarily led by two major vendors: Doppelmayr Garaventa Group and Leitner Poma. Our research found there were also many other vendors and manufacturers of components and equipment, which won't be covered in detail.

- Doppelmayr/Garaventa have over 14,800 ropeway installations in 6 continents.[5]
- Leitner has existed for over 120 years, and operates over 2,000 kms of ropeways.
- LST has focused expertise in urban systems, and has built over 700 worldwide.[6]

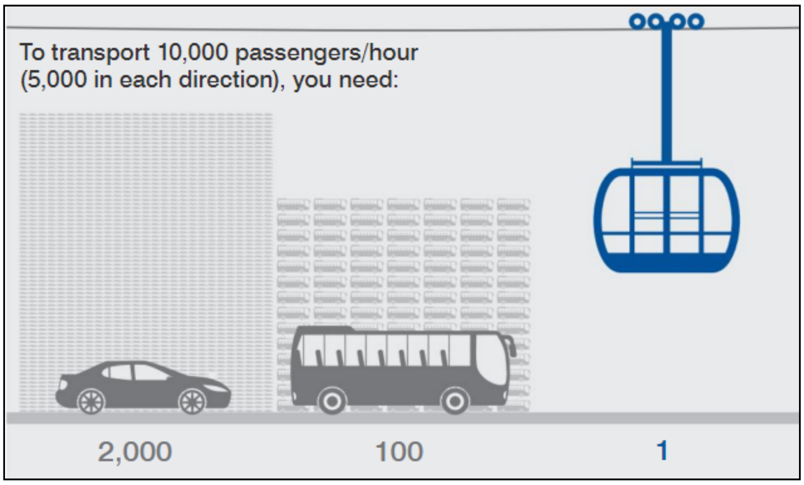
Edmonton is also home to several global construction leaders with proven capabilities in large transportation projects. PCL is building three gondola systems for Disney World and Stantec completed a feasibility study for the Town of Banff. Ellis Don is one of Canada's largest providers of P3 transit infrastructure (e.g. TransEd Partners consortium and the Valley Line LRT), and a gondola project could be an attractive project for private investment and partners like these given the revenue opportunities seen in other systems.

[3] http://www.cbc.ca/news/canada/edmonton/tired-of-getting-lectured-edmonton-mayor-suggests-partial-bike-ban-may-be-needed-for-high-level-bridge-1.3675851
[4] http://edmontonsun.com/2016/06/16/cyclists-and-pedestrians-concerned-with-narrowed-high-level-bridge-will-have-to-wait-five-years-for-possible-widening/
[5] https://www.doppelmayr.com/en/the-group/facts-and-figures/
[6] http://www.lsturbanropeways.eu/en/

Benefits and Characteristics

High Capacity Mass Transit

- Modern urban gondolas can transport up to 4,000 - 6,000 passengers per hour, per direction (pphpd), depending on the design and technology selected.[7]
- A 5,000 pphpd system is roughly equivalent to 2,000 private vehicles or 100 buses.[8]
- Given that this is comparable to the capacity of the urban low-floor LRT design (the standard for future LRT projects), we consider urban gondolas to be a 'high capacity mass transit solution' rather than just a tourist attraction as some may initially think.
- To contrast, our existing high-floor LRT has the following capacity based on a full 5-car configuration and 200 passengers per car:
  - 10,400 ppdph Capital Line South of Churchill and 8,000 ppdph North of Churchill
  - 2,400 ppdph Metro Line North of Churchill



Infographic source: Doppelmayr

- An assessment conducted to evaluate a proposal for an urban gondola in Austin Texas cited a service capacity of 3,600 to 6,000 passengers per person per hour depending on system type and configuration[9].

Type of System	Monocable	Bicable	Tricable
Cabin Capacity	15 passengers	16 passengers	35 passengers
Transport Capacity	3,600 passengers/hour	3,600 passengers/hour	6,000 passengers/hour

Source: Texas A&M Transportation Institute and Texas A&M University

[7] Cable Car Confidential, Steven Dale
[8] https://www.doppelmayr.com/en/applications/urban/urban-brochure/
[9]https://www.mobilityauthority.com/upload/files/board_meetings/2017-03-29/14_0_FINAL_AIS_EDs_Report.pdf

Fast and Efficient Mass Transit

- In urban gondola systems, the maximum speed and average speed is roughly the same, unlike other modes of transit which must make frequent stops, wait at stations, and are impacted by traffic signals, congestion, and road construction.
- When making comparisons, it's important to look at average speeds, not maximum speeds since buses and LRTs do not travel at maximum speeds along routes.
- Detachable grip technologies allow gondola cabins to slow down or stop at stations without affecting the flow of the entire system.
- Urban gondolas have average speeds ranging between 21 km/h to 29 km/h (depending on design).
- Gondolas also travel a direct straight line that is the shortest distance between stations. Buses/cars must meander through corridors on the road network.

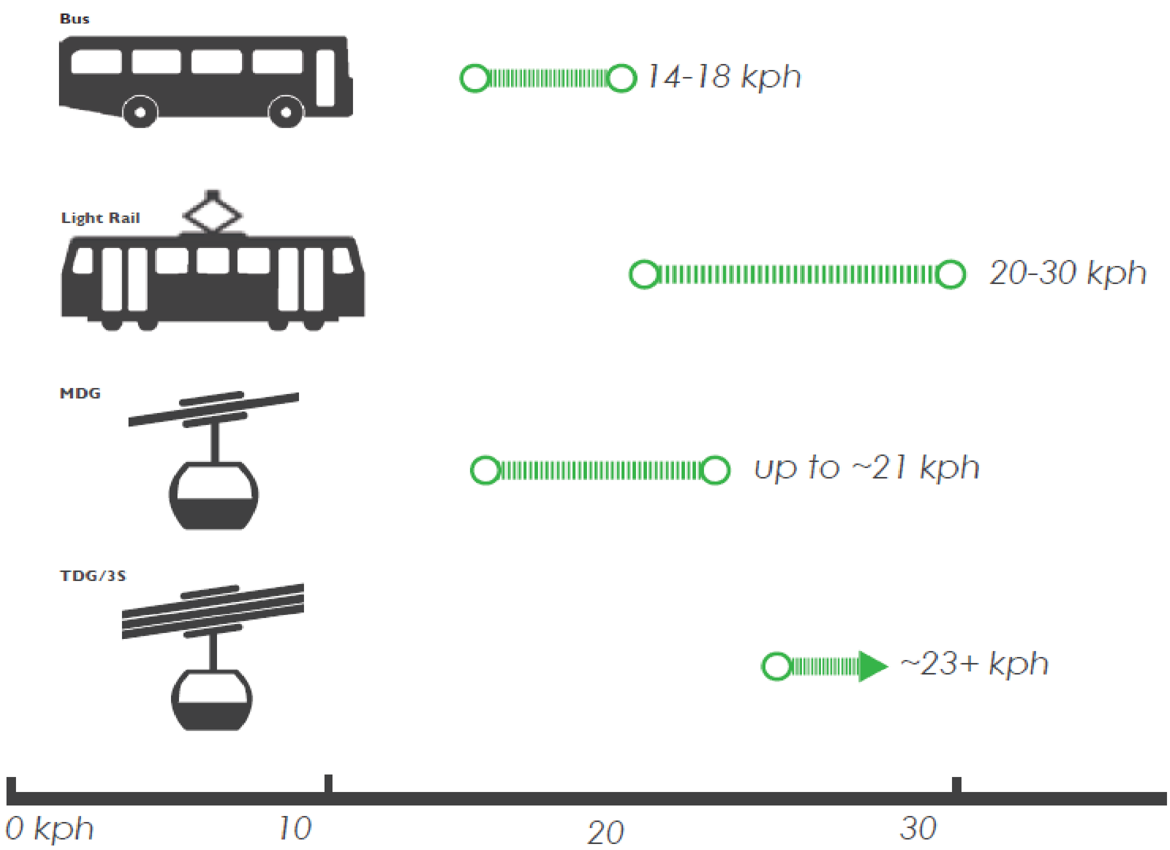
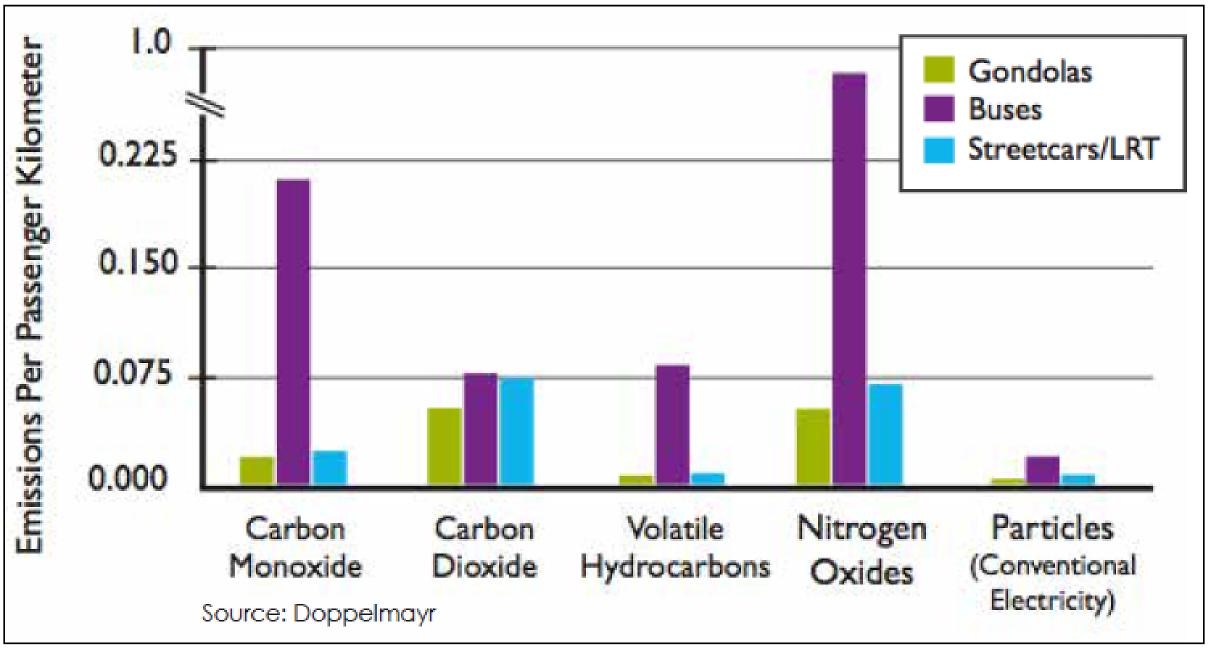


Image Source: Cable Car Confidential

Environmentally Friendly / Low Ecological Footprint

- Urban gondolas have one of the lowest power consumption requirements of any transit mode - the energy required per person and per kilometer are much lower than electric buses or streetcars due to the ratio of payload (passengers) to self-weight.[10]
- Urban gondolas run continuously which means less electricity is used to overcome the rolling resistance of stop-and-go traffic that is typical to terrestrial systems.
- Gondolas don't have the added weight of a drive mechanism or fuel in the vehicle[11].
- Modern ropeways consume about 0.1 kWh per person per kilometer based on a capacity of approximately 3,600 people per hour per direction. The NY's aerial tram consumes a mere 0.06 kWh per person per ride to carry passengers nearly 1 km.
- Energy demand increases as capacity and speed increases, similar to other modes. Operators can reduce speeds outside of peak travel times and increase speeds during peak commuting times to minimize energy consumption. (This strategy is employed in Medellin's cable car system in Columbia).
- Unlike cars and buses, cable cars produce no point source emissions.



Urban gondolas can also support green energy targets by being equipped with solar panels on the roof of each cabin to improve environmental sustainability. This can be used to reduce consumption or power visual displays or intercoms in the cabins.

Source: Cable Car Confidential, Steven Dale

[10] https://www.doppelmayr.com/en/applications/urban/urban-brochure/
[11] http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1470&context=jpt

High Reliability Transportation

- System reliability is extremely high, ranging from 99.3% to 99.9%[12].
- An interview with the GM of Portland's Aerial Tram revealed they experienced only 17 minutes downtime in 2017, during over 560,000 trips. (99.99% reliability)
- During Hurricane Irene and Superstorm Sandy, the New York Roosevelt Island Tram was able to operate longer than all other forms of transit, and was the first to resume operation.[13]
- Urban gondolas are very resilient to extreme weather conditions given they are originally built in mountainous regions with extreme weather conditions.
- At least one backup motor is built into all systems, ensuring that passengers can safely be returned to stations if there is a rare power outage or engine failure.
- Downtime from bad weather is usually the result of high wind speeds; although new technologies allow operation at wind speeds upwards of 100 km/h. Different designs have different wind-tolerance thresholds, ranging from 70 km/h to over 100 km/h.

Negligible Impact on Traffic

- Unlike buses, private vehicles or LRT, service cannot be impacted or slowed due to traffic congestion or physical obstacles such as a vehicle collisions, road construction or out of service LRVs on the tracks.
- Urban gondolas have virtually no impact on traffic flow due to their grade separation with street level traffic. They add capacity without contributing to road congestion.
- Their modular and prefabricated design also means there is minimal impact during the short construction phase.
- It is extremely costly to grade separate other modes of transit like bus or LRT, as demonstrated by previous studies conducted by the City of Edmonton. To raise the Valley Line West LRT above only two intersections (178th ST and 149th ST) would have cost an extra $240 million.[14] Although these costs depend on many factors, examples from previous transportation studies illustrate the enormous expense.

Able to span long distances

- The longest monocable detachable gondola is an 8.8 km long line in Turkey.[15]
- Branson, Missouri signed a MOU to build a 13.6 KM urban gondola line with 10-12 stations along a popular and heavily trafficked strip of theatres, museums, tourist attractions and finally ending at an amusement park[16].

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[12] Cable car confidential - Steve Dale
[13] https://www.amny.com/transit/roosevelt-island-tram-facts-and-figures-1.11764786
[14] https://globalnews.ca/news/4080794/edmonton-transit-west-lrt-valley-line-cost/
[15] https://en.wikipedia.org/wiki/Bursa_Uluda%C4%9F_Gondola
[16] http://gondolaproject.com/2016/12/15/branson-gondola-city-approves-mou/

Minimal waiting times for passengers

- Urban gondolas are continuous movement transport systems which means there are no schedules or timetables - only the headway between cabins. This means minimal and predictable wait times since passengers can always see the next cabin coming.
- This characteristic will make integration with existing transit seamless since schedules of other modes of transit don't need to be aligned or synchronized.
- The only exception are aerial tramways which entail two cabins traveling back and forth from the two terminal stations. This is the design used in Portland, Oregon which is already experiencing capacity constraints since the success and popularity of the system was underestimated while it was being planned.

Barrier-free mobility for all

- Level platform access easily accommodates any mobility aid (wheelchairs, scooters, etc.) with effortless access for baby strollers, bicycles and luggage.
- Gondola cabins are slowed to a crawl speed or even brought to a complete stop at stations without slowing the entire system, allowing passengers to comfortably board and disembark. This is enabled by detachable grips which remove the cabin from the propulsion cable, thus keeping the system running at close to max speed.
- Cabins can have foldable seats to provide more space for wheelchairs.
- Station stop announcements can be played in the cabins and stations to help guide passengers with visual or hearing impairments.

Image credits (Left to Right): (Doppelmayr Urban Brochure[17] , Leitner Ropeway in Berlin; YouTube[18])

Minimal Wait Times and Seamless Integration with other ETS services

- Since gondola systems are continuously moving and circulating between stations, there is minimal complexity in integrating with other modes of public transit. There is no need to align frequencies or timetables since cabins arrive at predictable intervals.
- Wait times are a function of cabin frequency, capacity, speed and passenger demand; however most wait times to board are usually no more than a few minutes.

[17] https://www.doppelmayr.com/en/applications/urban/urban-brochure/
[18] https://www.youtube.com/watch?v=ahnPgM_j_Go

The Safest Mode of Mass Transportation

- Ropeways are statistically the safest means of transport.[19]
- There can safely operate in extreme weather conditions such as wind speeds upwards of 100 km/h. Advanced systems can have electrical grounding systems that protect riders from lightning strikes.
- Cabins can be equipped with security cameras as well as audio/visual communication systems that are centrally monitored. This can allow for announcements to be broadcast and accommodate two-way communication.
- The design is highly resilient and is designed to remain operational even if an individual technical component fails.
- Attendants can be placed at each station; and this is financially viable since there is no need for drivers and ticketing will be automated.
- Cable propelled systems have 1 death per 900 million passengers, whereas transit systems have 1 death per 31 million passengers.[20]
- In Switzerland, cable car riders are 3 times less likely to be injured than in a tram, bus or train, and 50 times less likely to be injured than in a car.[21]
- Statistics in North America show that from 1990 to 2010, there have been no fatalities in enclosed gondola cabins, and only six fatalities involving chairlift type ropeway installations. In comparison, transit systems had 5,681 fatalities.[22]
- Cabin recovery technology allows cabins to always be safely returned to stations without the need for on-line evacuations.
- For example, the Roosevelt Island Tram has a motor that is equipped with both electric and gas power, as well as a wireless retrieval system. The Tram also features a dual-haul system, meaning each cabin can operate independently.
- Unlike other electric mass transit options such as LRT and streetcars, there are no dangerous high-voltage power lines since the drive power is provided centrally.
- A number of cabins could be designated only for female passengers during late night service if there are possible safety concerns from some potential passengers.
- Strict regulatory standards ensure all components are built to handle four times the expected maximum load.

[19] https://www.doppelmayr.com/en/applications/urban/urban-brochure/
[20] Cable Car Confidential, Steven Dale
[21] Seilbahnen Schweiz. (2012). Seilbahnen und Skilifte: Mit Abstand das sicherste Verkehrsmittel. Retrieved from http://www.seilbahnen.org/Sicherheit.html
[22] Fletcher, J. (2009). Future perspectives of ropeways in north america. Oitaf-nacs, Lakewood, Colorado. Retrieved from http://adr.coalliance.org/cog/fez/view/cog:176

Rapid Construction / Short Building Phase

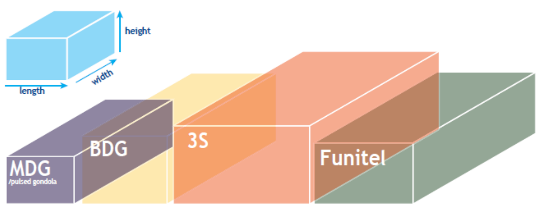
- Most simple gondola lines can be built in less than one year[23].
- Due to the minimal infrastructure requirements compared to BRT or LRT, there is minimum disruption to traffic. Most of the traffic impacts occur when towers and other large equipment are being transported or assembled.
- Most of the components are prefabricated, built off-site and are simply assembled on site. (Drive system, line/ropes, towers, control systems, rollers, cabins/gondolas, etc.)

Images (Clockwise): Lutsen Gondola, Russia [24], Mexicable (Ecatepec, Mexico)[25], Berlin, Germany[26]

Minimal space requirements / land needs

- Stations and towers have a very small footprint. Since towers can be spaced out, the City would not need to procure/pave/develop much land, unlike other modes of transit. Furthermore, the land that would need to be acquired does not need to be an entire linear corridor but only accommodate stations and towers.
- Basic station size requirements are minimal; the largest configuration (TDG/3S) only requires 38m (length) by 20m (width) by 11.5 m (height).

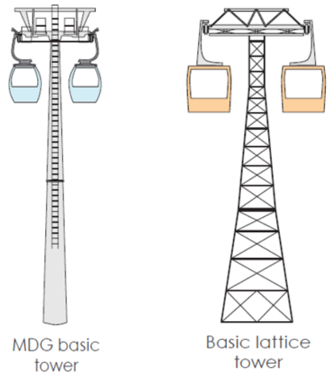
TECHNOLOGY	LENGTH (M)	WIDTH (M)	HEIGHT (M)
MDG/Pulsed	29	10	7
BDG	32	12.5	10
TDG (3S)	38	20	11.5
Funitel	36	14.5	9
Aerial Tram	n/a	n/a	n/a



[23] Cable Car Confidential, Steven Dale
[24] http://northernwilds.com/new-gondola-at-lutsen-mountains/
[25] https://mexiconewsdaily.com/news/new-cable-car-system-to-be-operational-soon/
[26] http://www.breakingtravelnews.com/news/article/leitner-begins-gondola-ropeway-ahead-of-berlin-garden-show-2017/

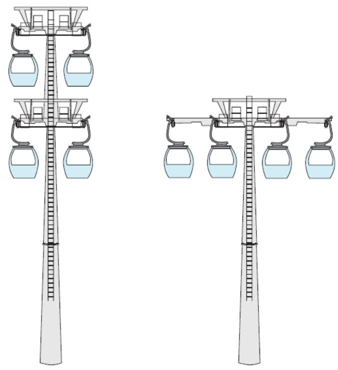
- Depending on the technology, towers can spaced between 0.5 kms to 3 kms, and have a very small footprint as shown in the table below.
- Tower heights vary to suit the terrain; Singapore's systems has 80m towers.

TECHNOLOGY	TOWER SPACING (M)	TOWER TYPE	TOWER FOOTPRINT (M)
MDG/Pulsed	100-300	Steel Cylinder	0.6 - 1.5 m diameter
BDG	up to 1500	Steel Cylinder	2-3m diameter
TDG (3S)	up to 3000	Steel Lattice	25m²
Funitel	500-1000	Steel Cylinder	2-3m diameter
Aerial Tram	n/a	n/a	n/a



Source: Cable Car Confidential, Steven Dale

Expandable and Scalable Design Systems



- Stacking: system capacity can effectively be doubled by operating two loops per route/alignment. This requires minimal changes to tower footprint and cost, however should be determined during the design phase.
- Systems can also be lengthened by adding an additional loop at the terminal stations.

Images / visuals: Cable Car Confidential, Steven Dale

Luxurious, Modern Cabins with Inspiring Designs

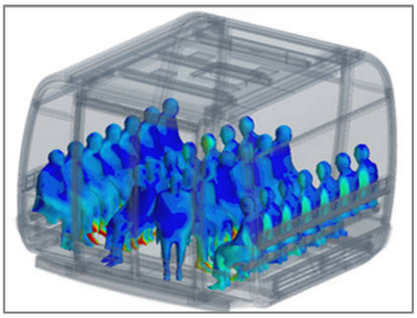
- Cabins can be luxurious and offers lots of passenger comforts.
- Wi-Fi can power infotainment systems, advertising or useful passenger information.
- Smart glass technology is available which allows windows to switch from clear to opaque when cabins travel over areas with privacy concerns like residential areas.
- Cabins offer panoramic views with some featuring glass floors to enhance the view.
- Climate control with variable airflow and ventilation is available. Heating is available in the winter and air conditioning for the summer. Heated seats are also an option.
- Exterior bike racks which can support up to 20kg suspended[27] (or bikes can be transported in a standing area in the cabin, depending on the configuration).

Image credits (clockwise from top left): Pininfarina design[28], Taris 3S cabins by Swiss manufacturer CWA[29], Téléphérique de Brest (France)[30].

[27] https://www.doppelmayr.com/en/components/sports-equipment-carriers/sports-equipment-carriers-for-cabins/
[28] http://www.pininfarina.it/en/symphony/symphony.htm
[29] http://gondolaproject.com/2013/05/01/the-new-taris-3s-cabin-from-cwa/
[30] https://www.francebleu.fr/infos/faits-divers-justice/telepherique-de-brest-la-cabine-fait-une-chute-de-plusieurs-metres-et-s-ecrase-au-sol-1502367178

Customizable cabin size to suit ridership

- Most gondolas have between 4-28 seats, with additional room for standing. There are many commercial options available; seating configuration is fully customizable.
- Aerial tram cabins can accommodate up to 200 people.



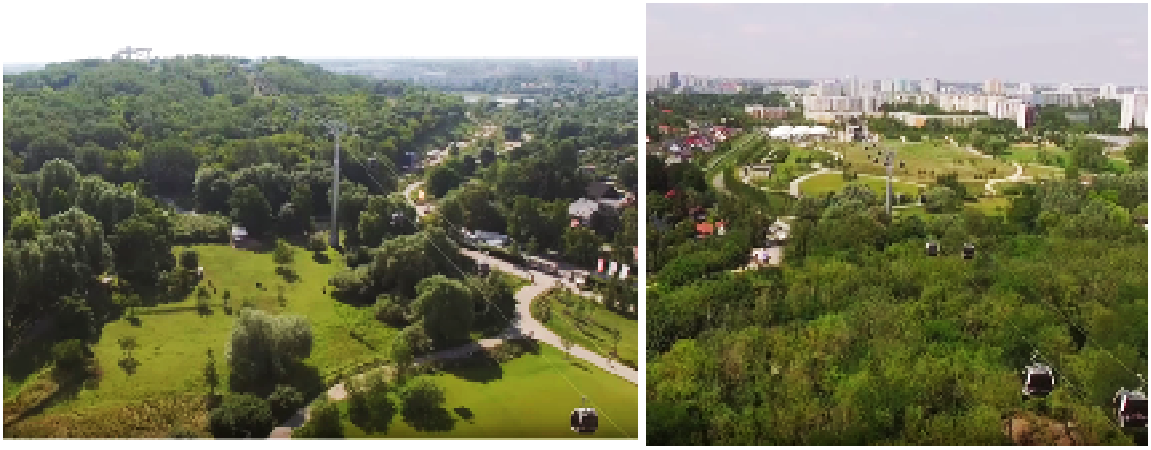
Competitive Cost/Benefit Ratio compared to other mass transit

- More detailed information on capital, operating and maintenance costs is included in the 'Business Case and Financial Considerations' section.
- The costs vary significantly depending on the number of stations and their design, the type of gondola system, topographical challenges and amount of customization.
  - Stations are the most costly part of projects, with the electro-mechanical equipment costing as little as 7% of total project costs in some cases[31].
- Lower capital / infrastructure costs than BRT and LRT projects.
  - The capital costs per kilometer for a gondola project typically range from $9 million to $60 million (USD) per KM, with the Emirates Air Line in London being an outlier at $82 million per KM. To contrast it costs the City of Edmonton an average of $138 million per KM to build LRT tracks, excluding any bridges that would be needed to traverse the river valley (detailed information and sources in the Business Case section)
- Low operating and maintenance costs. (Between $3 - $9 million USD per year, typically ranging between 5-10% of total project implementation costs)[32]
- Fully automated operation is possible.
- Vendors can be responsible for managing operations as well as spare parts and maintenance management; there is no need to develop a large in-house maintenance team.
- Several of the systems we researched and facilitated interviews with, including London's Emirates Air Line and Portland's Aerial Tram, generate revenues that exceed their operating and maintenance costs (revenue positive systems).

[31] Interview with Steven Dale of Creative Urban Projects and the Gondola Project
[32] Multiple sources (Stantec feasibility report for Banff, interviews with other systems)

Least intrusive infrastructure to span the river valley

- An urban gondola system would be the least development-intensive way to connect the two sides of Edmonton's river valley. Compared to any other mode of mass transit, it would require the least amount of land to be acquired and developed.
- The small station and tower footprint minimizes construction activity, and facilitates the final solution being architecturally blended in with the natural environment.
- The impact to biological resources including vegetation would be minimal.



Source: Berlin Gondola ("Gärten der Welt" in Berlin)[33]

Image: Metrocable to Medellín's Parque Arvi [34]

Quiet Operation

- Gondolas create minimal noise pollution since they require no on-board motor, which should be a key consideration in high-density urban areas.
- The only noise will be in the stations from all the moving components.

[33] https://www.youtube.com/watch?v=ahnPgM_j_Go
[34] https://yainis.com/medellin-colombia/

Tourism Benefits and Unique way to access and enjoy the River Valley

- An urban gondola with 360 degree panoramic views across the river valley would be a major draw for visitors and tourists. It would provide spectacular and unobstructed views of the river valley, making it a must-see for everyone. By way of comparison, the High Level Bridge Streetcar is currently ranked #4 / 194 things to do in Edmonton on Tripadvisor.[35]
- In addition to being an iconic attraction itself, it would also provide a fast connection between Downtown and Old Strathcona, and make it easier for visitors to see more destinations and attractions in each neighbourhood.
- In 2016 Edmonton saw 3.3 million overnight visitors, a 3.5% increase over the previous year. That same year, international visitors increased by 7.1%[36]. Tourism Alberta reported a record $8.5 billion spent in Alberta by 35 million visitors in 2016[37]. Combined with the investments and bids Edmonton has made to host international sporting events, it is safe to anticipate tourism numbers will continue to steadily grow.
- Give that cabins can be heated and offer protection from the elements, it would be an attractive activity year round, aligning well with our Winter City Strategy.
- Cabins can be equipped with full glass floors for unique and exhilarating views.[38]

Images:Awana Skyway in Malaysia[39], Ngong Ping 360 gondola in Hong Kong[40]

[35] https://www.tripadvisor.com/Attraction_Review-g154914-d1030648-Reviews-High_Level_Bridge_Streetcar-Edmonton_Alberta.html
[36] https://globalnews.ca/news/3928048/edmonton-tourism-numbers-up-3-5-over-2016/
[37] http://edmontonjournal.com/business/local-business/alberta-tourism-spending-sets-8-5-billion-record
[38] https://www.leitner-ropeways.com/en/company/references/gd10-awana-skyway-3093/
[39] https://blog.malaysia-asia.my/2017/03/awana-skyway-glass-bottom-gondolas.html
[40] https://www.klook.com/activity/6981-ngong-ping-360-crystal-cabin-hong-kong/

Limitations

There are some limitations which must be taken into consideration when seriously contemplating an urban gondola project or evaluating a proposed design or route alignment.

Some of the main limitations to consider include:

- Although *average* travel speeds are similar to other modes of transit, *maximum* speeds are significantly lower suggesting that urban gondola systems are only ideal for shorter distances in dense urban environments. This highlights that they are more complementary to a city's transit system rather than a substitute for other forms of mass transit which are more appropriate for connecting distant nodes.
- Lack of flexibility in the route. Although capacity can be increased significantly through different means, the route is fixed similar to LRT systems and cannot be adjusted or modified. To contrast, bus routes can be completely re-routed to better meet demand and travel patterns while incurring minimal costs. This suggests the route should be carefully planned taking into consideration current and forecasted travel patterns and road traffic data.
- Most gondola systems can operate only when wind speeds are less than 70-100 km/h depending on the design. A feasibility study should take into account how frequently these conditions occur in the proposed route, and how much downtime is acceptable.
- Limited stops for passengers to disembark. Similar to LRT, passengers can only disembark at stations, which cannot be placed exceedingly close to one another due to their high cost. Station location should be carefully thought out to maximize ridership.
- Although urban gondolas have many failsafes, backup motors, and an evacuation drive, if all of these systems experienced a complete failure, it would be difficult to rescue people from the cabins.
- Misinformation and public skepticism. Any such project is guaranteed to be subjected to a high degree of criticism and cynicism due to its novelty and lack of ubiquity in most transit systems. Project champions and political leaders should be clear about what transportation problem is being solved, be able to clearly communicate the objectives and expected benefits, and have sound rationale for why a gondola makes the most sense compared to other alternatives.
- Residents of any neighbourhood the gondola passes over may have legitimate and serious concerns about an intrusion to their privacy. Depending on how problematic this may be, smart glass can be installed which can automatically turn opaque when passing over certain areas.
- Some individuals have fears of heights that may prevent them from being able to ride an urban gondola.

- People have different tastes and different opinions - some people will think that a gondola soaring above the neighbourhood will detract from the visual appeal of the area, or may ruin the existing look and feel of the neighbourhood.
- Based on the experience of other jurisdictions, successful implementation of gondola systems occur when the gondola option provides an answer to a challenging situation (for example steep slopes or river or freeway crossings).

Proposed Route and Rationale

The following section describes and provides rationale for a proposed route which will maximize the benefits to the City and best demonstrates the unique capabilities and benefits of a gondola system. ETSAB has defined the route evaluation criteria below, and has included transit ridership and commuter traffic statistics along the route to demonstrate the growing need for more cost-effective transportation along this corridor.

Screening and Evaluation Criteria

Criteria	Route		
	Whyte Ave & Gateway to Downtown	University to Fort Edmonton /Valley Zoo	University to Bonnie Doon Mall
Challenged Topography (major elevation changes)	🟢	🟢	🔴
Difficult or Expensive to Service via Conventional Transit Modes	🔵	🔵	🔴
Limited Number of Discrete Destinations	🟢	🟢	🔴
High Passenger Volume Potential	🟢	🔴	🔵
Limited Impacts to Existing Development	🟢	🔵	🔴
Public Right-of-Way / Lands	🟢	🔵	🔵
Serves as Transit for Commuters	🟢	🔴	🔵
Potential for Tourism	🟢	🟢	🔵

Legend

🟢 = Yes / Strong Potential

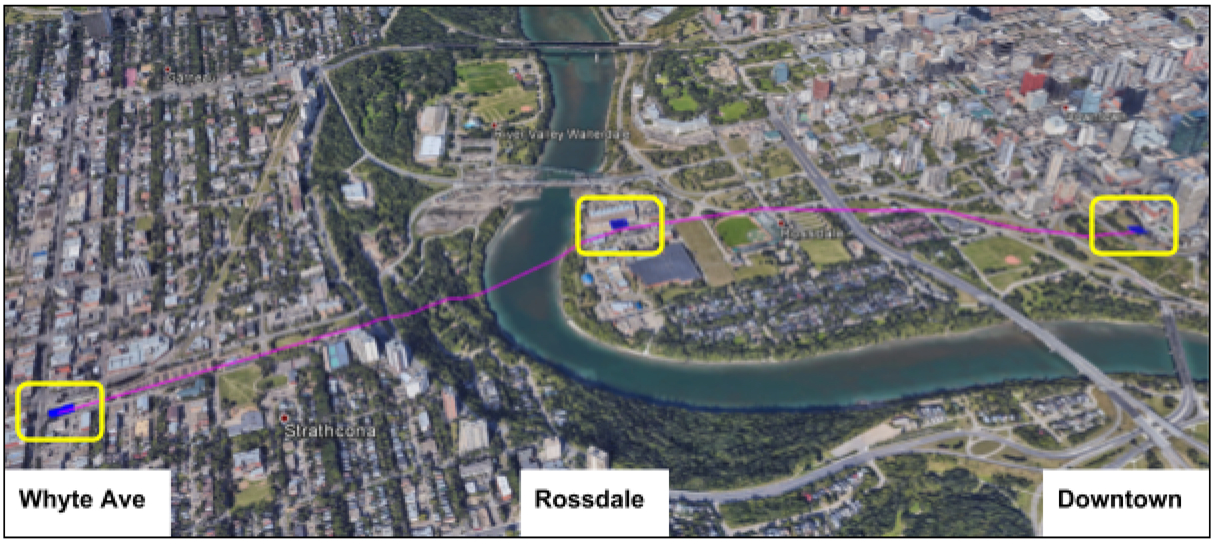
🔵 = Moderate

🔴 = No / Weak Potential

Proposed Route, Alignment and Stations

The genesis of our consideration for a gondola within the transit system was the challenge of connecting the hearts of Downtown and Whyte Avenue. ETSAB believes the most logical route from both a ridership and net City benefit perspective will be to connect the Downtown area and Old Strathcona community, with a station at the Rossdale complex possible either opening day or in the future as the area is developed. An urban gondola has the potential to be a catalyst for the Rossdale site as a future urban residential and commercial-cultural space. The Quarters Downtown would also become much more accessible to a larger commuter shed, aiding its development.

The example route alignment shown below illustrates a preferred route of how an urban gondola could seamlessly connect three important and future growth areas that are difficult to service with conventional transit - the Downtown, Rossdale, and Old Strathcona.



Rationale for a Station Downtown (Telus Plaza / 100 St & McDougall Hill Area):
This area has the potential to be the front porch to Downtown, and is at the confluence of major roads in to the core. It is also at the nexus of major transit routes and one block from the LRT Capital Line and future Valley Line, with existing underground pedway connections. McDougall Hill challenges transit busses and autos alike to climb its grade, with the difficulty increasing in winter conditions.

In addition to the existing connectivity with transit throughout the core and proximity to Edmonton's Financial District commercial offices and Civic Quarter, it is within easy walking distance to The Quarters. Edmonton has bet big on The Quarters Downtown becoming a vibrant, healthy, and flourishing community that will be the future home of up to 20,000 residents.[41] There has been over $500 million in public and private investment to date, and the City is seeking partners to build on the momentum. Two key guiding principles in the

[41] https://www.edmonton.ca/projects_plans/the-quarters-downtown.aspx

area design plan are to incorporate sustainable principles and improve circulation in and around the Quarters by strengthening connections[42]. An urban gondola would be a unique opportunity to provide the neighbourhood with high quality, pedestrian-friendly mass transit that supports a mode-shift to more active modes such as walking, biking and utilizing public transit, and could greatly expand the area's transit shed- making it much more desirable for investment.

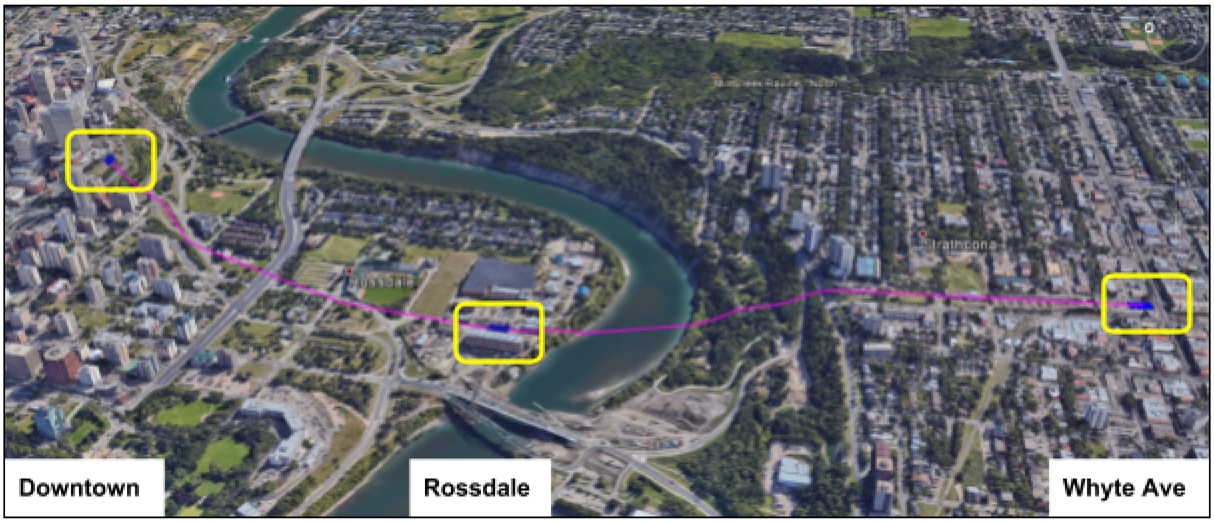
Rationale for a Rossdale station:
In 2011 the City of Edmonton approved the long-term vision for West Rossdale and a vibrant urban redesign plan. Three of the strategic priorities established are to:

1) Promote and integrate sustainable transportation alternatives;

2) Make the area a destination for residents and visitors; and

3) Enhance West Rossdale as a main entrance or gateway to the Downtown.[43]

An urban gondola would satisfy all three objectives without negative externalities like increased vehicular and bus traffic and noise. Furthermore it would improve the environmental sustainability of the area and provide fast, efficient, and reliable mass transit to Downtown and Old Strathcona.

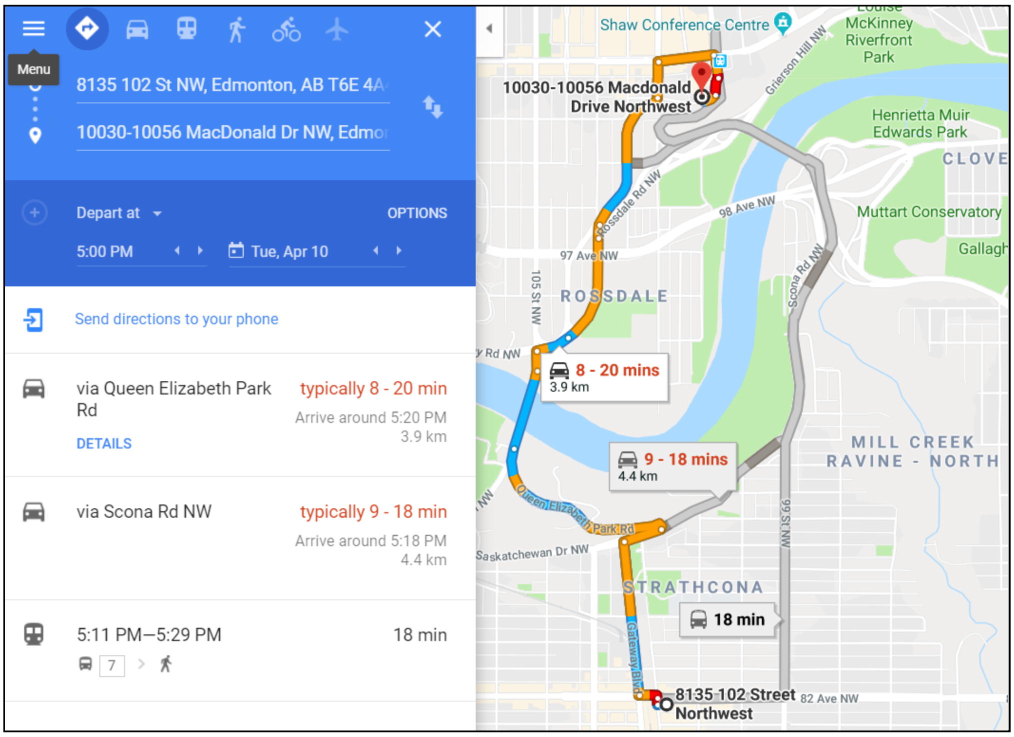


Rationale for an Old Strathcona Station:
Old Strathcona is a vibrant and historic community that is hub for many Edmonton festivals, tourism, attractions and visitors. It is one of Canada's five best shopping neighbourhoods[44], and home to some of Edmonton's best dining, nightlife and entertainment. It is however notoriously difficult to get Downtown, with public transit to Central Station taking between 15 to 30+ minutes. Taxis and rideshare options can cost upwards of $15 a trip. Most Edmontonians decide on which area to spend a night out in, but why choose?

[42] https://www.edmonton.ca/documents/PDF/09371COE_Urban_Design_Plan_Revision_LowRes_for_Download.pdf
[43] https://www.edmonton.ca/documents/PDF/West_Rossdale_UDP_CA.pdf
[44] https://exploreedmonton.com/attractions/Old-Strathcona

A scenic seven minute trip from Downtown to Old Strathcona would surely change that and help bring more downtown residents to explore and spend time in Edmonton's best neighbourhood 4 years running[45]- and make it easier to travel back and forth. For the regular commuter, it would introduce a fast and easy method of mass transit between the two destinations, which may in the future link to LRT, BRT, or other transit options along Whyte Avenue.

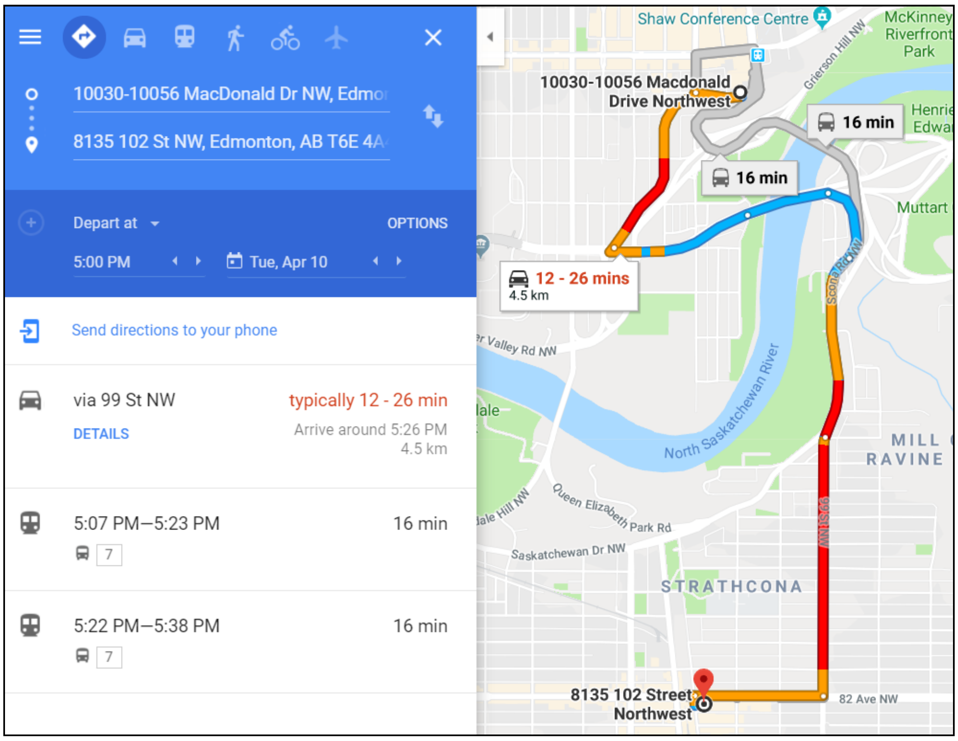
Although the total straight-line distance between the three example nodes is roughly 2.5 km, vehicles must travel a minimum of 3.9 km on the road network. By car it takes 8-20 minutes depending on traffic congestion, of course with extra time required to find parking. By bus the trip will take at least 18 minutes, unless you miss the bus and must add at least 15 mins wait time. A gondola traveling at an average speed of 25 km/h could complete the trip in under 7 minutes, regardless of road conditions or traffic volumes.



Source: Google Maps (estimated trip time in weekday afternoon rush hour at 5 PM; Whyte Ave to Downtown)

[45] https://exploreedmonton.com/attractions/Old-Strathcona

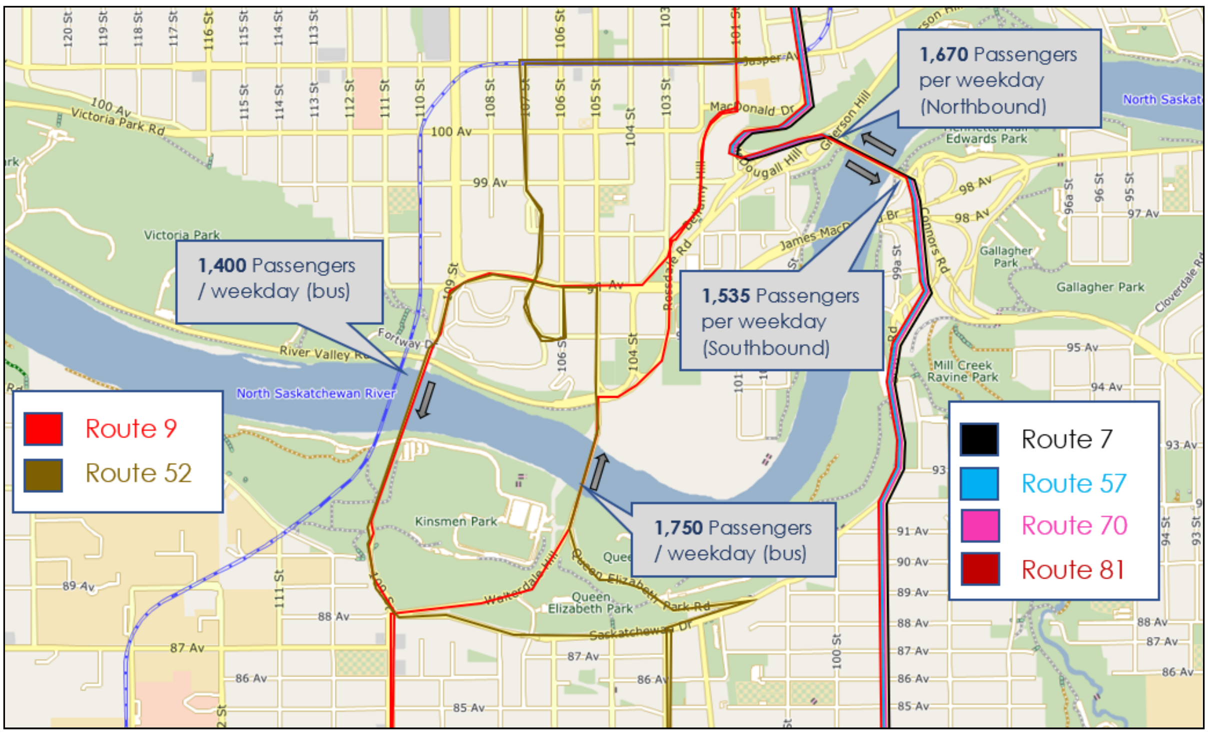
Travelling with traffic at the PM peak, transit times are similar, though driving can take anywhere from 12 to 26 minutes:



Source: Google Maps (estimated trip time in weekday afternoon rush hour at 5 PM; Downtown to Whyte Ave)

Current Ridership and Travel Volumes Along the Route

ETSAB obtained current ridership data for buses traveling north and south across the River Valley as a potential indicator of possible demand. The graphic below details the total bus ridership along the four bridges connecting Downtown and Old Strathcona. *(Data from ETS)*



In terms of vehicular traffic, it is estimated there are over 136,000 cars crossing those bridges every day[46]. Given that a gondola trip combined with other ETS services could actually shorten the total trip time for some Edmontonians commuting to the Downtown area, it is reasonable to expect that such a project may incent a mode shift for a small percentage of drivers. Consider this: more often than not, public transit is cheaper but not faster than driving, so people opt for the latter. If public transit is both cheaper and faster than driving, why wouldn't we expect more people to adopt public transit?

The following table represents daily passenger loads provided by ETS, and include all bus ridership traveling along the High Level bridge, Walterdale bridge and Low Level bridge.

Bus Traffic	Routes	Weekday	Saturday	Sunday	Weekly Total
South along High Level Bridge	9, 52	1,400	900	700	8,600
North on 105th Street Bridge	9, 52	1,750	1000	850	10,600
Low Level Bridge Northbound	7, 57, 70, 81 & 87	1,670	430	230	9,010
Low Level Bridge Southbound	7, 57, 70, 81 & 87	1,535	410	220	8,305

Source: ETS data from Automatic Passenger Counters on buses in September and December 2017

The projected growth and increasing density of both the Downtown and Whyte Ave area will mean we can expect an increase in demand on the existing road infrastructure. Any conventional public transit solution, whether LRT, BRT or running additional buses will contribute to congestion on the roads. An urban gondola would have a small footprint, be environmentally sustainable, and alleviate congestion as ridership grows.

Alternate Routes

ETSAB has taken notice of recent comments regarding interest in gondola routes, specifically one proposed along the Whyte Avenue corridor. Our position based on the research is that the best use case to demonstrate the benefits of urban gondolas would be north/south across the River Valley, given the rationale provided above.

As noted within the Limitation section, successful gondola implementation occurs when addressing a challenging problem. As currently demonstrated Whyte Avenue does accommodate successful bus service, and the road network could be re-designed to incorporate LRT or other mass transit. As such, the Whyte Avenue gondola corridor does not provide the same level of opportunity as crossing the North Saskatchewan River.

46 http://www.cbc.ca/radio/thecurrent/the-current-for-march-16-2018-1.4577977/march-16-2018-full-episode-transcript-1.4580157

Business Case and Financial Considerations

This section provides some comparative financial data from other systems in operation. It is important to note that by drawing attention to the cost-effectiveness and financial viability of such a project, ETSAB is not necessarily advocating that this should be a purely publicly funded project. There are opportunities to attract and encourage private investment or partnership, or even pursue a public private partnership (P3) agreement similar to how the Valley Line LRT will be financed and operated. Given that some gondolas we researched are net revenue positive, this should be a viable and attractive option for private industry.

Capital Costs

- Capital costs for urban gondola solutions are typically a fraction of the cost of other dedicated right-of-way mass transit solutions such as BRT or LRT.
- Given that there are many variables that impact total cost, there is no reliable 'cost per km' or other reliable formula to extrapolate from. Rather, ETSAB has provided the capital, per km and operating costs for numerous other systems as a point of comparison. Data was compiled from other research reports and publications.

	Daily Ridership	Annual Ridership	Implementation Cost in USD (year) [Electro-mechanical]	Cost per Kilometer in USD [Electro-Mechanical]	Fare Cost (USD, 2011)	Daily Op. Hours
COMPLETE SYSTEM INTEGRATION						
Medellin Line K	~35,000	12,000,000	$26,000,000 (2004) - [N/A]	$13,000,000 [N/A]	~$1.00	19
Medellin Line J	~15,000	5,000,000	$50,000,000 (2008) - [$26,000,000]	$19,200,000 [$10,000,000]	~$1.00	19
Caracas Metrocable	~5,000	~2,800,000	> $21,000,000 USD	> $9,000,000 USD	~$0.25	15
Teleferico do Alemao	~13,000	~4,000,00	$133,000,000 (2011) - [$26,500,000]	$38,000,000 [$7,600,000]	~$1.00	17
Constantine Telecabine	7,000	2,500,000	$14,000,000 (2008) - [$8,300,000]	$9,300,000 [$5,500,000]	~$0.25	12
Tlemcen Telecabine	1000-6000	N/A	$14,700,000 (2009) - [$9,400,000]	$9,200,000 [$5,900,000]	~$0.25	17
Skikda Telecabine	N/A	N/A	$16,200,000 (2009) - [$10,500,000]	$8,500,000 [$5,500,000]	~$0.25	17
Roosevelt Island Tram	6,400	2,400,000	$25,000,000 (2009) - [$25,000,000]	$25,000,000 [$25,000,000]	$2.25	22

	Daily Ridership	Annual Ridership	Implementation Cost in USD (year) [Electro-mechanical]	Cost per Kilometer in USD [Electro-Mechanical]	Fare Cost (USD, 2011)	Daily Op. Hours
PARTIAL SYSTEM INTEGRATION						
Portland Aerial Tram	3,800	1,350,000	$57,000,000 (2007) - [N/A]	$57,000,000 [N/A]	$4.00	16
Medellin Line L	4,200	N/A	$25,000,000 (2010) - [N/A]	$5,200,000 [N/A]	~$1.50	9
Emirates Air Line	~2,500 - 25,000	N/A	$90,000,000 (2012) - [N/A]	$82,000,000 [N/A]	$6.85	11-14

	Daily Ridership	Annual Ridership	Implementation Cost in USD (year) [Electro-mechanical]	Cost per Kilometer in USD [Electro-Mechanical]	Fare Cost (USD, 2011)	Daily Op. Hours
RECREATIONAL SYSTEMS						
Koblenz Rheinseilbahn	~35,000*	N/A*	$17,900,000 (2010) - [$13,200,000]	$20,100,000 [$14,800,000]	~$12.00	8-10
Teleférico Warairarepano	N/A	840,000	$45,000,000 (2000) - [N/A]	$12,900,000 [N/A]	$8.25	9-11
Ngong Ping 360	~4,200	1,480,000	$128,700,000 (2006) - [N/A]	$22,600,000 [N/A]	~$10-22	8
Singapore Cable Car (Rebuild)	2,000-4,000	900,000	$14,700,000 (2010) - [$14,700,000]	$8,600,000 [$8,600,000]	~$21.50	14.5
Bolzano Funivia del Renon	N/A	N/A	$22,300,000 (2009) - [N/A]	$5,000,000 [N/A]	~$5.00	14

Source: Cable Car Confidential, Steven Dale

System	Length (Km)	Year built	Number of stations	Capacity pphpd	Daily Ridership	Annual Ridership	Construction cost	Fare (one-way)	Operating cost
Telluride (Colorado)	5	1996	4	900	7,000	2,600,000	$16,000,000	Free	$5.1M
Roosevelt island tram (New York)	1	1976 (rebuilt 2010)	2	1,000	6,400	2,400,000	$25,000,000	$2.75	$3.9M
Portland Aerial Tram (Oregon)	1	2007	2	980	3,800	1,350,000	$57,000,000	$4.55	$2.7M
Emirates Air Line (London)	1.1	2012	2	2,500	25,000	1,600,000	$90,000,000	$8.00	$9.4M offset by $10.6M in generated revenue
Medellin Line J (Columbia)	2.6	2008	4	3,000	15,000	5,000,000	$50,000,000	$1.00	N/A
Caracas Metrocable (Venezuela)	1.8	2010	5	1,500	5,000	2,800,000	$21,000,000	$1.00	N/A
Tlemcen (Algeria)	1.6	2009	3	1,500	6,000	5,000,000	$14,700,000	$1.00	N/A

Source: Banff Long Term Transportation Study prepared by Stantec (July 2016)

- Capital costs depend on many factors, the most significant being the number of stations and their design. The electrical equipment can be as little as 7% of the total project cost. At a high level, the cost per kilometer can range from $10M to $150M.[47]
- Major factors impacting costs include the extent of customization, topographical challenges, the design of the system, the technology used, the number of cabins, as well as consultants and scope creep.
- A recent pitch for an urban gondola along a similar route, which won the Edmonton Project design competition, estimated that the cost for a basic gondola system covering a similar route would be between $20 million and $60 million[48].
- The land acquisition costs are minimal due to the small footprint of these projects, given that towers can be spaced up to several kilometers apart.
- Despite a great deal of variation between each of the above systems, none of the projects cost more than $100 million, which is a fraction of what it would cost to refurbish let alone construct a new bridge across Edmonton's river valley.

[47] Interview with Steven Dale, Creative Urban Projects
[48] https://globalnews.ca/news/4067608/gondola-over-the-north-saskatchewan-the-edmonton-project/

    - To contrast the difference in initial capital costs, it has been cited it costs the City $138 million per kilometer to build LRT tracks[49].
- The Portland Aerial Tramway was a completely custom built system that was inaugurated in 2006 at a cost of $57 million USD. Rather than opt for standard towers and cabins, the chosen design originated from an international design competition and featured custom built cabins, towers and stations. About $6-8 million of that construction cost was to insulate the top station with a rubber gasket to prevent any vibration so as not to interfere with microsurgeries at the adjoined hospital.
    - The City's portion of the project, about $8.5 million, is expected to be recovered over time solely via rising property values in the district[50].
    - They found that for every ¾ mile of LRT, they can build a whole tram.
    - In considering alternatives, the city found that 1 mile of urban 4 lane freeway costs between $60 - $300 million.
- Stantec estimated for the Town of Banff that the capital cost of a 5 km monocable detachable gondola system would cost approximately $66 million, factoring in a 20% contingency ($13 million per km), with annual operating costs of $5.8 million.
- A 2016 feasibility study for a gondola connecting Georgetown in Washington DC to Rosslyn in Arlington, Virginia estimated the total capital costs to be $80-$90 million, with operating costs of $3.2 million. The project was deemed feasible. It could be built decades before a metro at a fraction of the cost. [51]
    - This is based on a 1.1 KM monocable line crossing a river with a capacity of 2,400 people per hour per direction and a 20-60 second frequency.

Revenues

- One aspect that was surprising in the research is that numerous overhead cable propelled transit systems are revenue positive and are actually able to cover their operating and maintenance costs.
- Portland's Aerial Tram is one such system, where fare revenue more than pays for the City's portion of operating and maintenance costs, not to mention the additional tax revenue they enjoy from higher land and property values in the area.
- To contrast, the average cost recovery ratio for ETS is currently about 40%.
- The Emirates Air Line in London, which operates at ridership numbers much lower than capacity (<10%), is still revenue positive with fares exceeding operating costs. It also benefits from a 36 million GBP sponsorship deal with Emirates ($65M CAD).
- Other sources of potential revenue include advertising opportunities or naming rights.

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[49] http://www.cbc.ca/news/canada/edmonton/tram-gondola-edmonton-portland-new-york-1.4576948
[50] http://www.gobytram.com/about/
[51] http://www.georgetownrosslyngondola.com/feasibility-study/

Operating and Maintenance Costs

- Unlike other forms of transit, increasing the passenger capacity is not correlated to increases in operating costs since the personnel overseeing the operation are relatively fixed. The graph below shows how operating costs for cable-propelled transit remain relatively flat as capacity is increased, as compared to the linear increases seen in bus and tramway systems.

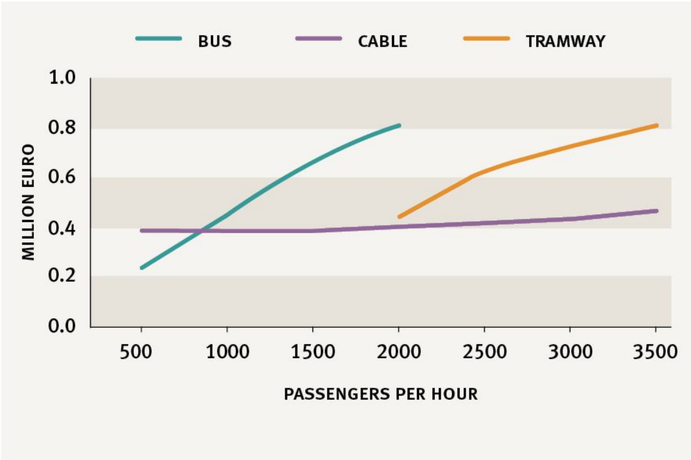

FIGURE 1 INDICATIVE COMPARATIVE COSTS BASED ON OPERATING COSTS OF BUS, TRAM AND ROPEWAY WITH HOURLY PATRONAGE IN GRENOBLE, FRANCE

Source: Steer Davies Gleave: Are cable cars a viable form of urban mass transit?[52]

- A key benefit for gondola systems from an operational cost perspective is that they have no deadhead time, unlike buses which must incur costs as they travel empty to and from the garage from the route's starting point.
- Similarly, since all maintenance is performed on-site, there is no need for expensive and large real estate intensive buildings and garages to store and maintain the equipment/vehicles.
- Roughly speaking, operating and maintenance costs can be estimated at 10% of a system's total implementation costs[53], although they are less than half of that for Portland's Aerial Tram.
    - Portland's Tram has an operations and maintenance budget of about $2.5 million annually, equally split between operations and maintenance. It serves an annual ridership of 2.25 - 2.3 million with greater than 99.9% reliability.
    - Annual revenue from ticket sales more than covers the City's portion of costs.
- The Emirates Air Line in London has operating and maintenance costs of about 3.1 million GBP annually, with customer service operations costing an additional 1.4 million GBP on average. [54]

[52] http://www.steerdaviesgleave.com/news-and-insights/cable-cars
[53] Cable Car Confidential, Steven Dale
[54] Information provided by Head of Engineering at Emirates Air Line

Electricity Needs

- Electricity needs for a system depend on a number of factors including system speed, capacity, design and the number of cabins.
- Modern ropeways consume about 0.1 kWh per person per kilometer based on a capacity of approximately 3,600 people per hour per direction.
- The aerial tram in New York consumes a mere 0.06 kWh per person per ride to carry passengers nearly 1 km across a river.
- Portland's Aerial Tramway utilizes about 375,000 kWh annually and does more than 2.25 million trips annually. (< 0.17 kWh per passenger per 1 km one-way trip)
- The London Emirates Air Line utilizes an average of 1.2 million kWh annually.

System Life-Cycle

- System components typically are designed to last 20-30 years, whereas the stations and towers have a longer lifespan of about 50 years. Longevity is similar to LRT (25-30 years), and superior to buses (10-12 years).
- The Roosevelt Island Tram in New York was built in 1976 and underwent a major refurbishment in 2010, exceeding its original life expectancy of 17 years. The station foundations and original towers were kept as they were structurally sound.
- Portland's Aerial Tramway has an expected life cycle of 50 years.

Construction Times

- Most simple cable projects can be built in under one year's time due to the minimal infrastructure requirements. Gondola systems have a significantly shorter building phase than alternatives such as building or even refurbishing existing bridges. There are numerous prominent examples in Edmonton's recent history of how much bridge refurbishment projects can cost, as well as how long they take to complete.
- Most of the components/parts are manufactured off-site and are simply assembled on-site.
    - This minimizes construction costs and any congestion due to construction activities.
    - Similarly, this lessens the impact, noise and inconvenience to surrounding businesses and residents during construction.

Transit Oriented Development (TOD) Opportunities

- Based on examples from other cities, most notable and relevant being the success of the Tram in Portland, Oregon, cable transit projects have the potential to serve as a significant catalyst for transit-oriented development and neighborhood investment.
    - In Portland there was a perception that the aerial tram would hurt property values.
        - However, no residents chose to take the city up on their offer to buy their homes at market value when given the opportunity. The tram ultimately increased property values substantially.
    - South waterfront was previously an old underutilized industrial area – since the aerial tram was installed, there has been billions of dollars in development including residential, condo/high rise, new hospital buildings, mixed use offices, retail, food and nightlife – all marketed as ‘tram accessible property.’
    - Following the success of the tram project, Portland’s public transit system has expanded to better serve tram commuters, rather than the Tram being designed to tie into existing public transit hubs.
- If the project is planned in conjunction with urban renewal or neighbourhood revitalization projects, this can maximize the benefits and opportunities for residents, businesses and developers.
- The City of Edmonton expects that residents in the Quarters Downtown area will increase nearly 10-fold to 18,000 - 20,000 residents. There has already been $500 million in public and private investment in that area, and a gondola system could further entice businesses to invest in developing that underutilized area, given its proximity to a possible downtown station and increased access to other areas of Edmonton.
- For many years the City of Edmonton has planned an urban redesign to transform the West Rossdale neighbourhood. A gondola system with an interim station in Rossdale could be a major incentive for redevelopment and a great perk for residents.
- The gondola cable car lines in Medellin, Colombia not only provided mass transit to previously underserved communities, they decreased homicide rates in those areas by approximately 66%, and incidents of violent crime by 75% when compared to control neighbourhoods.[55]

[55] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3353133/

Case Studies, Best Practices & Lessons Learned

Example System Profiles

While there are only several overhead cable propelled public transit solutions currently operating in the U.S. — Portland, Oregon's Aerial Tram and New York City's Roosevelt Island Tramway — numerous more are being built[56]. There have been many more proposals and feasibility studies completed, with findings that demonstrate their feasibility and advantages over other conventional transit modes[57]. The technology is quickly gaining traction in European countries such as Italy, Germany, Portugal and France.[58] The list of cities considering gondola solutions is vast and growing.[59] See Appendix A for more details.

Portland Aerial Tramway (2006)

The tram travels a horizontal distance of 1,000 m and a vertical distance of 150 m in a ride that lasts three minutes (traveling at 35 km/h). Trams arrive on a seven minute frequency and have a capacity of 78 people per cabin.

The Tramway connects the south waterfront area to Portland's biggest employer, the Oregon Health and Science University (OHSU). It was critical to provide fast, efficient and reliable transit to OHSU, which is challenging because it is at the top of a large hill. They experimented with shuttles and buses but this was inefficient and costly; the trip by bus took as long as 25 minutes whereas only 3 mins by tram. They considered every option and the only feasible one was an overhead cable propelled transit solution.

Image credits (Left to Right): Share Oregon[60]; OHSU Transportation and Parking[61]

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[56] https://wdwnt.com/2017/04/walt-disney-world-gondola-system-foundation-construction-begin/
[57] http://www.georgetownrosslyngondola.com/feasibility-study/
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[61] http://www.ohsu.edu/xd/about/services/transportation-and-parking/tram/index.cfm

Ridership
There has been a huge growth in ridership to the point that they are now facing capacity issues. Between 2.25 - 2.3 million riders are served annually. There are 9-10k trips daily from Monday to Friday and about 2-4k on Saturdays; it is closed on Sundays.

The ridership breakdown is roughly 85% hospital based (OSHU is a teaching and research hospital that is the biggest employer in the city), and 15% general public and tourists.

Integration with Public Transit and Alternate Modes
The lower tram station is a multi-modal transit hub, with great access to light rail, five bus routes and bicycle parking. This level of integration has contributed to its success and ridership rates. It is interesting to note that the public transit system connected to the tram following its huge growth in ridership, not the other way around. The Portland Aerial Tram has the largest bicycle valet in North America - all offered for free. More bikes park at the bottom of the tram than anywhere else in North America.[62] Bikes are also permitted on the tram.

New York's Roosevelt Island Tramway (1976; refurbished in 2010)

- Originally built in 1976, it connects Roosevelt Island with the Upper East Side of Manhattan. It was reopened after a major renovation in 2010 and has transported over 26 million passengers.
- Trip time is 4 minutes and travels ~1 km at nearly 30 km/h, climbing over 250 feet.
- Each cabin carries up to 125 people and makes approximately 115 trips daily.
- The tram has 15 minute headways from 6:00 a.m. to 2:00 a.m. (3:30 a.m. on weekends) and runs continuously during rush hours.
- Fares are the same as the NYC Subway, and the same metrocard is used to board.
- In 1989, the subway was expanded connecting Manhattan to Roosevelt Island, however the tram remains very popular today and is considered a complementary solution given that it was refurbished in 2010 rather than removed.

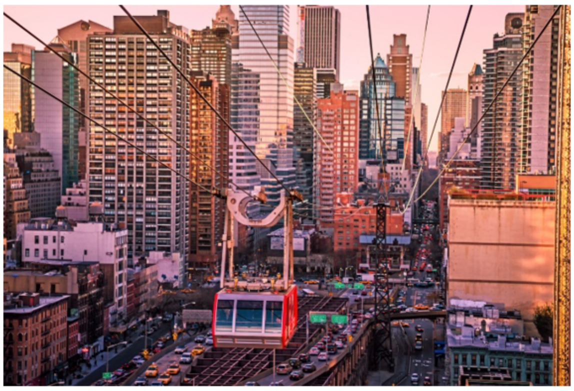


Image credits: (left to right): Michael Jiroch[63]; SCJ Alliance[64]

[62] http://www.ohsu.edu/xd/about/services/transportation-and-parking/tram/index.cfm
[63] https://www.youtube.com/watch?v=f6QcsQA0a-c

IGA Cable Car in Berlin, Germany (2017)

- The 1.5 km gondola was built in under one year at a cost of €14M. The journey takes only five minutes and has a capacity of 3,000 passengers per hour. This is accomplished by 62 gondolas, each with a 10 person capacity.[65]
- Although originally designed as an attraction rather than a mass transit solution, it has been a huge success with nearly 3 million journeys taken in just 6 months. 60% of visitors came from the German capital itself[66].
- Nearly 35,000 passengers were recorded on peak days.
- Talks with the Berlin authorities were planned to be launched in late 2017 to develop closer ties with the city's public transport system and improve the link between the Marzahn and Hellersdorf districts in a sustainable manner, in light of the new subway station behind the ropeway station.

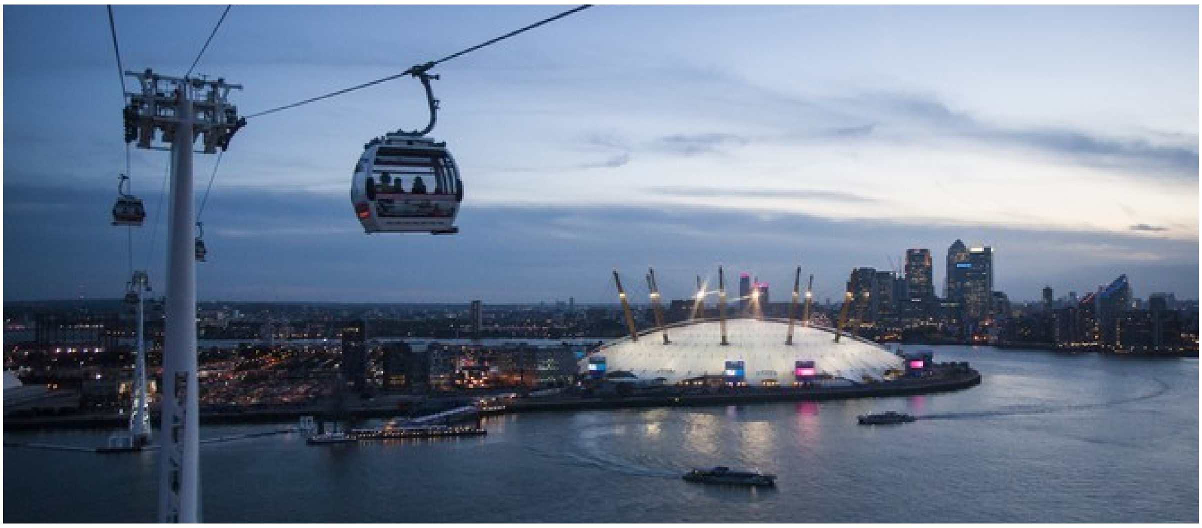
Source: LEITNER Seilbahn Berlin

Emirates Air Line cable car, London, England (2012)

- The monocable detachable gondola connects Royal Victoria to north Greenwich, across the Thames River.
- Annual ridership is about 1.5 million (28,000 riders/week), which is equal to London's 407th busiest bus line. Commuter ridership is very low give that the gondola is seen as a tourist attraction versus a purely public transit option.
- Its capacity supports 2,500 people per hour per direction, however it only transports about 4,000 people on average daily (in both directions combined). Based on a 14 hour operating day, it currently operates at between 5-10% of total capacity.

[64] http://www.scjalliance.com/project/roosevelt-island-tramway/
[65] https://en.wikipedia.org/wiki/IGA_Cable_Car
[66] http://www.seilbahn.berlin/en/ropeway-berlin.html

- It follows a similar route to the Jubilee Line on the London Underground, and thus does not solve a unique transportation problem. It's primary purpose was to connect O2 Arena and ExCel Centre (Olympic venues).
- The construction costs for the 1km line were 60 million GBP (~ $100 million CDN). Construction time took about two years from inception to completion.
- Despite the lower than anticipated ridership, it is still revenue positive, with fare revenue exceeding annual operating and maintenance costs.
- The Emirates Air Line has the highest satisfaction rating of any of any transit mode in London, at around 93/100.



Source: Secret London [67]

Although many other systems could have been included in this report, ETSAB decided only to provide a brief overview of a few to keep the report brief. We encourage more comprehensive research into the best practices and lessons learned from other projects should the City or another stakeholder proceed with a feasibility study. The table below details some parameters from the systems we looked at, as well as a few others.

SYSTEM	DAILY RIDERSHIP	ROUNTRIP FARE (USD)	DISTANCE TRAVELED (METERS)	SPEED (M/S)	SPEED (MPH)	SERVICE HEADWAY	PEAK HOURLY CAPACITY	NOTES
Portland Aerial Tram (Portland, OR)	3,400	$4.55	1,000	10	22	5 mins	936	Free for OHSU patients, visitors, students, and employees
Roosevelt Island Tramway (New York, NY)	5,500	$5.00	940	7	16.2	8 min peak (15 min off-peak)	1,000	Same fare as MTA bus; Parallel subway link is available
Cologne Rheinseilbahn (Cologne, Germany)	800	$7.25	935	2.8	6	30 sec	1,000	Tourist Focus Car capacity: 4 passengers
Emirates Air Line (London, UK)	4,200	$14.00	$14.00	6*	13	30 sec	1,800	Tourist focus; Slows to 2 m/s after 7pm for views
Singapore Cable Car (Singapore)	3,400	$22.00	1,650	4	9	15 sec	1,400	Tourist Focus Car capacity: 6 passengers
Metrocable (Medellín, Colombia)	30,000 (total for 3 lines)	$0.50	2,800	5	11	12 sec	3,000	Public Transport Focus Free transfer from Metro
			2,100	5	11	12 sec	3,000	
			4,600	6.1	13.7	65 sec	550	
Georgetown-Rosslyn Gondola (DC/VA)	TBD	Modeled as $1.75 / $2.15 Metro Rail Fare	~ 1,100	Modeled as 4.5	Modeled as 10	Modeled as 1 min	TBD	---

Source: Georgetown-Rosslyn Gondola Feasibility Study (2016)

[67] https://secretldn.com/plans-champagne-karaoke-emirates-air-line-cable-car/

Lessons Learned from Other Cities / Projects

ETSAB undertook only cursory high-level research on lessons learned from some of the literature:

1. **Gondola design needs to respond to local climate conditions**
   The Emirates Air Line in London, which is a monocable, shuts down at winds up to 14 metres per second [31 mph]. That equates to about 30 days of downtime a year due to wind. Bi- or tri-cable systems provide for greatly enhanced stability allowing for operation during major winds (up to 100 km/h).

2. **Gondolas should be used to address a real problem**
   Where Gondolas are successfully implemented, they have responded to problems that could not be overcome by other options. Gondolas are successful in Medellín, Hong Kong, and Portland because of the challenging geographical conditions. Traditional Light Rail Transit and subways are not possible due to the elevation gain, and road infrastructure require switchbacks and inefficient access. Within Paris, gondolas are being implemented to address challenging access. The line transverses a main highway and will connect a community which is poorly served by public transit. It is anticipated that this gondola will reduce travel time by 20 minutes.

3. **Be clear about the project type, whether a mass transit solution or tourist attraction**
   In communities where gondolas have been built as a tourist attraction, success after implementation is difficult to sustain. Using the London example, ridership was high during the Olympics, however six months after it opened ridership declined. While London has over 30 million tourist visits a year, annual ridership is approximately 1.5 million people. If London has a difficult time promoting this as a tourist attraction, there is a real concern for Edmonton over-investing in a project purely for tourism promotion.

4. **Do not underestimate ridership**
   Portland's Aerial Tram is already approaching maximum capacity ridership, and cannot add capacity due to the system's design. Unlike gondolas, aerial trams are not scalable in that you cannot add more cabins; trams only have two cabins which travel back and forth between the two terminal stations. As a result they have cut all marketing and promotions since the service is already well-subscribed and cannot accommodate much more growth.

Appendix A - Comparative System Profiles of Urban Gondolas and Aerial Trams in Other Cities

System Name	City	Country	Opening Year	Line Length (miles)	Average Speed (mph)	Number of Stations	Number of Cabins in Service	Cabin Capacity	Peak Frequency (seconds)	Operational Capacity (PPHPD)
Proposed										
Wire One Austin	Austin, TX	USA	*Proposed*	8.7[1]	TBD	19	TBD	10	12	1,200
Capital District Gondola	Albany, NY	USA	*Proposed*	1.0	14	3	TBD	8	24	2,400
Bay to Balboa Park Skyway	San Diego, CA	USA	*Proposed*	2.0	14	4	141	8	12	2,400
Georgetown—Rosslyn	Washington, DC	USA	*Proposed*	0.7	10	2	TBD	10	60	TBD
Currently Operating Gondolas										
Cable Constantine	Constantine	Algeria	2008	0.9	13	3	35	15	22.5	2,400
Mi Teleferico – Red Line	La Paz	Bolivia	2014	1.5	11	3	427 (3 lines)	10	12	3,000
Mi Teleferico – Green Line	La Paz	Bolivia	2014	2.4	11	4		10	12	3,000
Mi Teleferico – Yellow Line	La Paz	Bolivia	2014	2.3	11	4		10	12	3,000
Complexo Do Alemao	Rio De Janeiro	Brazil	2011	2.1	13	6	152	10	12	3,000
Metrocable – Line K	Medellin	Colombia	2006	1.2	11	3	93	10	12	3,000
Metrocable – Line J	Medellin	Colombia	2008	1.7	11	4	119	10	12	3,000
Metrocable – Line L	Medellin	Colombia	2010	2.8	14	2	27	10	65	1,200
Emirates Air Line	London	England	2012	0.7	13	2	34	10	30	2,500
Koblenz Cable Car	Koblenz	Germany	2010	0.6	12	2	18	35	34	3,700
Ngong Ping Cable Car	Hong Kong		2006	3.5	17	2	112	17	18	3,500
Mexicable	Mexico City	Mexico	2016	3.0	11	7	190	10	12	3,000
Singapore Cable Car	Singapore	Singapore	1974; 2010[2]	1.0	9	3	81	6	15	1,400
Telluride Gondola	Telluride, CO	USA	1996	2.5	11	3	32	8	30	480
Metrocable—San Agustin Line	Caracas	Venezuela	2010	1.1	11	5	70	10	12	3,000
Currently Operating Aerial Trams										
Portland Aerial Tram	Portland, OR	USA	2007	0.6	22	2	2	79	300	936
Roosevelt Island Tramway	New York, NY	USA	1976; 2011[2]	0.6	18	2	2	110	450	1,500

Additional characteristics of comparative Urban Gondola and Tram Systems:

System Name	Clock Hours in Operation Daily	Daily Ridership	Main Topographic Feature	Construction Cost ($USD, in millions)	Fare (one-way ride unless noted)	Type of Gondola
Currently Operating Gondolas						
Cable Constantine	17	7,000	Deep valleys	NA	NA	Monocable
Mi Teleferico – Red Line, Green Line, Yellow Line	17	60,000 (all three lines)	Steep terrain/ Poor connectivity	$234 million (all three lines)	$0.43	Monocable
Complexo Do Alemao	12–15	NA	Deep valleys	$74 million	$1.50[1]	Monocable
Metrocable – Line K	13–18.5	43,000	Steep terrain/ Poor connectivity	$24 million ($2003)	$0.50	Monocable
Metrocable – Line J	13–18.5	22,000	Steep terrain/ Poor connectivity	$47 million ($2007)	$0.50	
Metrocable – Line L	13–18.5	NA	Steep terrain	$21 million ($2009)	$2.00	
Emirates Air Line	13–15	4,000–6,000	Body of water	NA	$4.25	Monocable
Koblenz Cable Car	8–10.5	NA	Body of water	$20 million ($2010)	$6.85	Tricable
Ngong Ping Cable Car	8–9.5	4,200	Body of water	NA	$24[1]	Bicable
Mexicable	15–19	NA	Poor connectivity	$87 million ($2016)	$0.30	Monocable
Singapore Cable Car	13.25	2,000–4,000	Deep valleys	NA	$24	Monocable
Telluride Gondola	16	NA	Steep terrain	$16 million ($1996)	$0	Monocable
Metrocable—San Agustin Line	NA	2,000–3,000	Steep terrain/ Poor connectivity	$18 million	NA	Monocable
Currently Operating Aerial Trams						
Portland Aerial Tram	8-16	3,800	Steep terrain	$57 million	$4.55[1]	
Roosevelt Island Tramway	18-19.5	4,000	Body of water	$6.25 million (1968; $22.6 million in $2006)	$2.50	

Source: Texas A&M Transportation Institute and Texas A&M University System[68]

[68]https://www.mobilityauthority.com/upload/files/board_meetings/2017-03-29/14_0_FINAL_AIS_EDs_Report.pdf

Appendix B - Sources

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Appendix C - Contributions and Recognitions

ETSAB would like to express gratitude to the following people for participating in interviews, sharing information and contributing to the research that informed this report:

Organization	**Contact Person(s)**
Creative Urban Projects Inc. The Gondola Project	Steven Dale
Portland Aerial Tram	Ray Gardner General Manager, Portland Aerial Tramway
Emirate Air Line, London	Jeremy Manning Engineering Lead, Emirates Air Line
New York Roosevelt Island Tram	Alonza Robertson
Gary and Amber Poliquin who submitted the Urban Gondola proposal which won the Edmonton Project design competition	Gary and Amber Poliquin