3S

Gondola Technology

In Urban Applications

Prepared by Leitner-Poma and SCJ Alliance for TransLink

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TRANSLINK

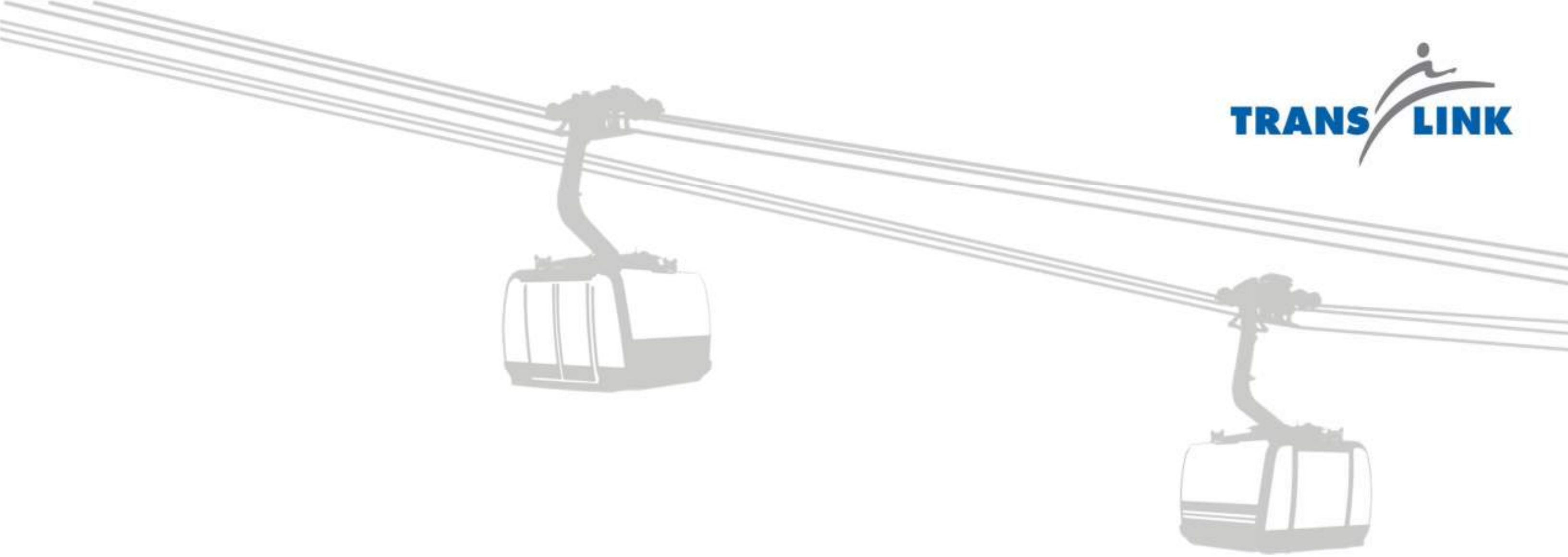

Table of Contents

What is a 3S Gondola?

A 3S Gondola is a ropeway transportation system. The broad category of ropeway transportation includes both aerial and ground-based technologies. The following lists categorize some of these technologies:

Aerial Systems
- Chair Lifts
- Gondolas
- Tramways

Ground-Based Systems
- Funiculars/Inclined Elevators
- People Movers

A 3S Gondola is a customizable system that provides high-reliability and high-capacity transit service and is well adapted to urban applications. Similar to gondola systems at ski areas, 3S Gondola systems transport passengers comfortably in gondola cabins from station to station. Towers support the system's cables between stations and ensure adequate ground clearance. To allow the gondola system to travel faster, span longer distances and carry larger cabins, 3S Gondola systems are supported by two large fixed cables that function like railroad tracks while a third moving cable propels the cabins.

Image 1 – 3S System in Bolzano, Italy

A 3S Gondola is both a detachable-grip system and a circulating system. These terms and other common 3S Gondola system terms are defined below:

Station:	The facility housing the equipment necessary to propel the system and anchor the cables. Stations can be terminals (end stations) or intermediate stations, located at turning points in the alignment or straight sections, and can be passenger boarding stations or pass-through stations. Pass-through stations typically occur at turning points.
Cabin:	The vehicle passengers ride from station to station.
Track Ropes/Cables:	The large wire rope cables that span from station to station and tower to tower that support the weight of the 3S Gondola cabins. Track ropes are fixed at each end at stations.
Haul Rope/Cable:	A continuous and looped wire rope cable that provides propulsion to the cabins. The haul rope wraps around large pulleys called "bull wheels" at the stations. The rope is propelled by a large motor attached to the bull wheel at one or more stations.
Grip:	The device that attaches the gondola cabin assembly to the haul rope. On a 3S Gondola system, the grip assembly or carriage has wheels that roll on the track ropes.
Detachable Grip System:	A ropeway system that allows the grip to detach from the haul rope in the stations. This feature allows the cabins to travel at a slow speed in the stations and at a higher speed between stations. The advantages of this system are a more comfortable passenger loading/unloading experience and a reduction in the travel time between stations. While the cabins are in stations, the grip assemblies supporting the cabins travel on a track system. By allowing the haul rope to continuously move at a high speed, the cabins traveling between stations do not need to slow down or stop for passengers to board and alight at the stations. The result is higher capacities than can be achieved in non-detachable (fixed) grip systems.

Tower:

A structure located between stations that supports the cables at an elevation necessary to provide suitable clearance. On towers, the track ropes are supported by long, grooved beams called "profile beams" which create a gentle transition for the cables. The haul rope is supported by a series of wheels called "sheaves" that rotate as the haul rope is propelled.

Image 2 – Components of a 3S Gondola System

Image 3 –3S Gondola Tower

3S Gondola System Parameters

Cabin Capacity:	Up to 35 passengers
Travel Speed:	Up to 8 m/s
System Capacity:	Up to 4,000 people per hour per direction
Systems Constructed:	15 worldwide
Systems in Construction:	8
Typical Maximum Wind Speed for Operation:	75+ kph

3S Gondola Systems Around the World	
Constructed Systems	**Systems in Construction**
• Avoriaz, France • Bolzano, Italy • Ischgl, Austria • Kitzbühel, Austria • Koblenz, Germany • Mayrhofen, Austria • Saas Fee, Switzerland • Sapa, Vietnam • Sochi, Russia • Solden, Austria • Stubai Glacier, Austria • Val d'lsere, France • Voss, Norway • Whistler, Canada • Zermatt, Switzerland	• Hunan Province, P.R. China • Jiangxi, P.R. China • Phu Choc, Vietnam • Toulouse, France • Verduchi Russia • Zhuhai, China • Zillertal, Austria

Environmental Conditions

3S Gondola systems are a robust technology, designed for harsh environments. In most weather conditions, 3S Gondola systems can operate safely and with high reliability.

Wind: The three cable configuration of a 3S Gondola system make the system very robust and safe, especially in windy conditions. Winds blowing parallel to the line have little impact on the system while winds blowing across the line have more impact. Similarly, steady winds have a lesser impact that gusty winds. While it is technically possible to operate in quite strong winds, the ride quality can be reduced as the limit is approached. While this is not a safety concern, passengers may feel unsafe and therefore choose not to ride the system. Slowing the operating speed of the system can aid in ride comfort and is often employed in these conditions. For a 3S system, this level of wind would likely impair or impact most forms of transportation including walking.

3S Gondola systems can be equipped with weather alert systems that keep operators informed of conditions and systems that measure the wind speeds at various locations and automatically alert the operators and slow or stop the system if desired.

Ice: 3S Systems are capable of operating in most icing conditions. In fact, continuing to operate the system is the best way to keep ice from forming on the cables and other mechanical components.

Evaluation of Ropeway Transportation

Ropeway transportation systems have a number of inherent advantages when compared to other urban transit system technologies. They also have some disadvantages. The following table lists some of these issues:

Advantages

- Proven Technology: over 20,000 ropeway systems worldwide
- Quiet
- Easily Integrated with Other Transit Technologies
- Less than 1 Minute Wait Time
- No Schedules or Timetables
- Excellent Safety Record
- Cost Effective Transit Solution
- Low Energy Consumption
- Electrically Powered: allows alternative energy sources
- No Point-Source Emissions
- Small Ground-Level Impacts
- Systems Can Integrate Automated Sanitization Systems
- Smaller Vehicles Promote Social Distancing

Disadvantages

- Possible Loss of Privacy for Properties Below and Adjacent to Alignment: mitigated by automatically tinting windows, window louvers and/or purposeful design of cable car height
- A Bend in an Alignment Typically Requires a Station: stations can be minimalistic non-boarding stations to save cost
- Some Riders May Have a Fear of Heights: reduced by larger 3S cabins
- Travel Speeds are Slower than Light Rail and People Mover Systems: offset by short wait times

Basic Design Principles

3S Gondola systems are a very flexible technology and by their nature they can fly above most of the natural and built environments. The following principals should be considered when planning a system:

- 3S Gondola systems typically follow straight lines. Bends and turns in an alignment typically require stations.
- 3S Gondola systems require some distance to increase and decrease in elevation when leaving a station or tower. Ride quality can suffer if abrupt transitions are implemented. The criteria for 3S Gondola systems is much less restrictive than other transit technologies. The maximum incline a bus, light rail train or people mover system can travel is significantly less.
- Systems can be extended or have additional segments spur-off of existing stations locations, but it is best to plan for possible expansion during the initial project phases.
- The weight of cabins, their equipment and passengers influence the size of system components and impact cost. The addition of amenities in cabins should be minimized where prudent.
- 3S Gondola systems can fly over structures and trees, but adequate clearance is required. Where possible, alignments should be planned to avoid crossing over structures.

Stations

3S Gondola stations are very flexible and can take on many configurations and shapes. The following describes the range of station geometry that is possible for this technology. Photographs of some examples follow this description:

Elevation:	The passenger boarding floor elevation must be a fixed distance below the cables, but the floor elevation can range from below ground-level to nearly any elevation above grade. The greater the elevation of the boarding floor level, the more substantial the station structure. Elevated stations can even straddle roadways.
Vertical Circulation:	Elevated stations require vertical circulation elements. This can include any combination of stairs, ramps, escalators or elevators. The design of the station should comply with all access and egress requirements. Vertical circulation elements can add significant cost to stations and the station design should consider this fact.
Enclosure:	3S Gondola stations require a minimum amount of enclosure to protect the system equipment, but any additional enclosure is flexible. Some station boarding areas are open to the elements while others are completely enclosed in a building.
Length:	The length of the station envelope must be long enough to include the gondola equipment and passenger boarding area, but can be much larger and include additional amenities.
Width:	The width of the station envelope must be wide enough to include the gondola equipment and passenger loading and unloading areas. Sufficient width should be included to accommodate the anticipated passenger flow. If passenger circulation areas are constricted, the overall system capacity can inadvertently be limited.
Form:	Stations can take on almost any form. Elevated stations can be supported on nearly any number of columns in nearly any configuration. This feature allows for the minimalization of impacts at ground level.

Architecture: Gondola stations are compatible with nearly any architectural style. The minimum requirement is that the equipment is suitably protected. Station architecture can have a significant impact on project cost and can easily represent the majority of project costs.

Construction Impact: Stations are very much like any building structure and their impacts are similar. The flexibility of elevated station structures allows for optimization of ground-level and utility impacts for support columns. During construction, conventional roadway traffic control and safety measures must be implemented.

Construction Phasing Example

One benefit of an elevated, column-supported station is the ability to close 1 to 2 traffic lanes at a time, construct the columns and their foundations in that zone, and then reopen that area to traffic. The following is just one example of a station support structure that minimizes traffic impacts:

- The station is supported by three lines of columns with each line running parallel to the roadway and consisting of 3 to 6 columns. See figures below.
- Two lines of columns are placed in opposite sidewalk areas, outside of sidewalk areas, or in curb bump-outs in parking lanes.
- The third line of columns is placed in a median barrier between traffic lanes near the roadway centerline.
- For this scenario, each line of columns requires only 1 to 3 traffic lanes to be closed for the construction of a line of columns and their foundations. After completion, the traffic lanes can reopen and other lanes can be closed for other construction of other column lines. See Steps 1, 2 and 3 in the figure below.
- Once all columns and foundations are constructed, one half of the traffic lanes can be closed and the platform level can be constructed between two lines of columns. After completion, traffic can be routed under the completed platform and the other platform can constructed over closed traffic lanes. See Steps 4, 5 and 6 in the figure below.
- Once the platform is completed, all traffic can resume and work can be conducted above the roadway with suitable protection and an occasional partial or nighttime closure of the roadway.

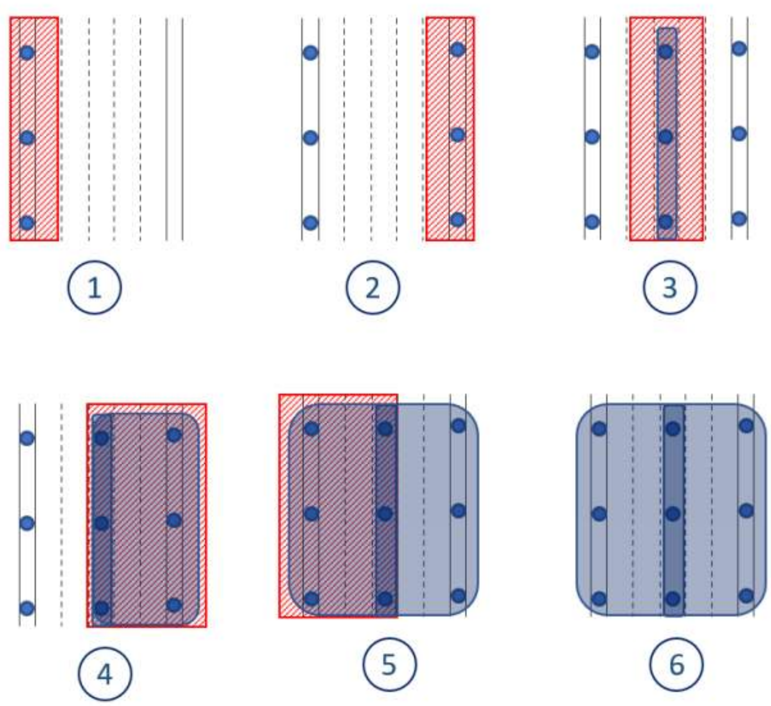

Image 4 – Station Construction Sequencing Example

Example Stations

Example of a minimally enclosed at-grade station.

Image 5 –Caracas, Venezuala

Example of an open-air station with at-grade boarding and only a simple equipment enclosure.

Image 6 – Cabárceno Park, Spain

Example of an elevated station straddling a roadway.

Image 7 – Ankara, Turkey

Example of a low-impact elevation station on steep terrain.

Image 8 – Station Concept Rendering

Example of a minimally enclosed elevated station.

Image 9 – New York City, USA

Example of a minimally enclosed elevated station.

Image 10 – Jackson Hole, USA

Example of a station integrated into a building. The system equipment extends beyond the building while the boarding area is inside the building.

Image 11 – Mexico City, Mexico

Example of an at-grade station with building-type architecture.

Image 12 – Mayrhofen, Austria

Example of an at-grade station with sophisticated architecture.

Image 13 – Kitzbühel, Austria

Example of an elevated station with sophisticated architecture.

Image 14 – Bolzano, Italy

Safety

At times, transit passengers can feel unsafe, especially at night or when a system is operating at low capacity. There are a number of advantages to an aerial gondola system:

- Once passengers are in a cabin and the doors close, they and the other passengers are in a safe space.
- Passengers can request to ride alone or only with people they know at low system usage times.
- In-cabin cameras and intercoms allows passengers to be monitored and request assistance from the operators during their ride.
- Some gondola operators implement woman-only cabins.

Gondola Support Towers

3S Gondola towers can also take on many configurations and shapes. Towers typically implement ladders or stairs for maintenance access. In some cases, construction-type elevators are installed to provide access to the tower top. The following describes the basic styles of towers. Photographs of some examples follow this description:

Lattice: Lattice towers are typically the most cost effective towers to implement and often have very low visual and ground impacts. While the aesthetics of lattice towers may be less interesting, the small structural elements and airy construction often make this tower type nearly disappear when viewed from a distance. Lattice towers typically have four legs and are typically supported by an individual foundation below each leg. The foundations that support this tower type can have very low impacts on the existing environment both during construction and when completed.

Tube: Tube towers are one of the most economical tower types. Consisting of a single, often tapered, vertical tube these towers have a simple yet appealing form. Compared to lattice towers, these towers tend to be more visible from a distance. The foundations for tube towers typically have a larger impact than lattice towers as the impact area is approximately two-times the base diameter.

Custom: Custom towers are often selected to make a statement and increase the aesthetic appeal of the system. These towers can be quite expensive and complicated to implement. While the form of these towers can be varies, making all towers of the same style can reduce the overall project cost. One should assume an impact area of approximately two-times the base area of the tower.

Regardless of tower type, the tower foundations can be designed to only project minimally above grade or to a sufficient elevation to protect the towers from vandalism and climbing. The exposed portion of the foundations can be architecturally treated to improve the appearance.

3S Gondola systems can be installed with Wi-Fi hot spots on towers to provide service to the entire route.

During construction, vehicle access is typically required for the delivery of materials and equipment, but it is possible to fully construct a tower and its foundations without road access by using helicopters and in situ jib cranes. The construction impacts can be very minimal and most sites can be returned to their previous condition following construction. Generally, a laydown area and space for a crane are required during construction. Long term road access is recommended for maintenance activities, but other solutions do exist.

Image 15 – Example of low-impact micropile foundation construction.

Example Towers

Example of a lattice tower with individual foundations.

Image 16 – Jackson Hole, USA

Example of a lattice tower straddling a road.

Image 17 – New York City, USA

Example of a lattice tower with elevated foundations.

Image 18 – Mayrhofen, Austria

Example of a tube tower with a single column.

Image 19 – Medellin, Columbia

Example of a custom tower.

Example of a tube tower with two support columns.
(note extended foundations)

Image 20 – Manizales, Colombia

Example of a custom tower.

Image 21 – Portland, USA

Image 22 – Moscow, Russia

Example of a custom tower with nighttime accent lighting.

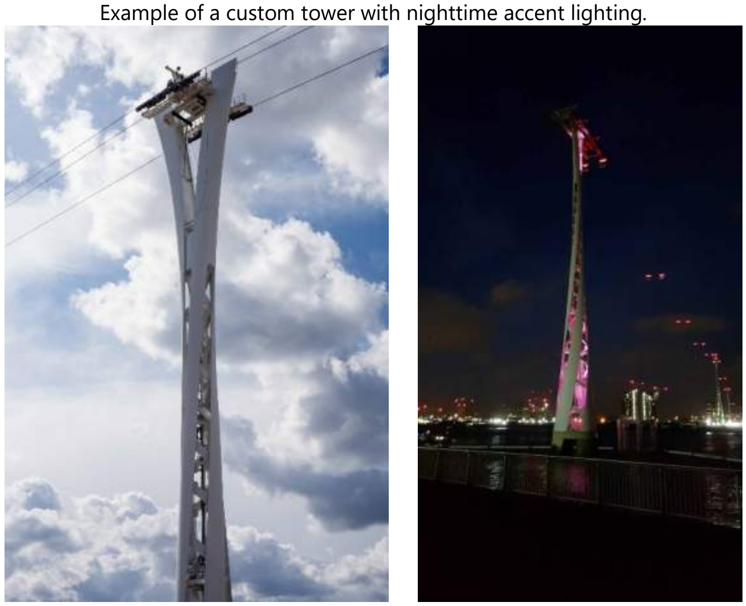

Image 23 – London, UK

3S Gondola Cabins

3S Gondola cabins are sophisticated transit vehicles. The following describes some of their features:

Size:	The cabin floor is approximately 3.7m (12 ft) square and the interior height is approximately 2.5 m (8 ft). Cabins are designed to comfortably hold the weight of up to 35 passengers in a number of configurations.
Windows:	3S Gondola cabins have large windows on all sides that create a pleasant viewing experience for riders. The large cabin size is typically sufficient to allow an interior space for passengers preferring not to look out a window.
Doors:	The cabins have a pair of doors on one side that slide outward to allow passengers to board and alight. The doors are automatically opened and closed by the system and lock when closed. Passengers do not have the ability to open the doors. There are emergency door releases accessible to trained personnel should the need arise.
Station Interface:	Cabins travel at approximately 0.25 m/s (1 fps) in station areas when the doors are open to allow comfortable boarding and alighting. The cabin doors typically remain open for 30 – 45 seconds. The cabin floor is at the same elevation as the station platform. The gap between the cabin and the platform is carefully adjusted to meet all accessibility standards.
Accessibility:	3S Gondola Cabins easily accommodate a variety of mobility devices and passengers utilizing these devices. The slow travel speed of the cabins through the stations allows most mobility device users easy access to this technology without assistance. Most systems provide attendants that can offer assistance when appropriate. If needed, the attendant can slow or stop the system for loading or unloading. If a cabin is slowed or stopped in a station, typically the entire system slows proportionately or stops as the entire system is synchronized. 3S Gondola Systems can be installed with auditory signaling for passengers experiencing vision impairment. In most cases, auditory signaling has been determined to not be necessary for safe boarding and alighting.

Bicyclists: 3S Gondola Cabins can easily accommodate passengers traveling with bicycles. Bicycles can easily be walked into cabins and held by the passenger. If desired, cabins can be outfitted with bike racks on the interior. The interior finishes of cabins can be designed to reduce wear and tear from bicycles. (See the following page for examples)

Manufacture: The cabins for 3S systems are typically manufactured by one of two European firms, Sigma Cabins and CWA. The cabins undergo significant design efforts and testing prior to going into production. This rigorous process results in extremely safe passenger vehicles. Due to the time and expense required to develop a new cabin design, custom exterior cabin geometry is seldom cost effective.

Image 24 – Sigma 3S Cabin

Image 25 – CWA 3S Cabin

Image 26 – Passengers Loading Cabins

Image 27 – Passengers with Bicycles

While the cabin structure is a fixed product that cannot be efficiently customized for one project, there are many components that can be customized:

Exterior Graphics: Cabins can be customized with graphics and painted to suit the location. Cabins can also have exterior accent lighting which adds flair as the cabins travel through the air.

Image 28 – Examples of Custom Exterior Graphics

Exterior Illumination: 3S Gondola cabins can be outfitted with decorative accent lighting to increase the visual appeal during nighttime operations.


Image 29 – Examples of Exterior Signage

Seating Configuration: Cabins can be provided with a wide array of seats and nearly any configuration. Configuration can range from 26 fixed seats to zero seats, maximizing the space available for standing passengers. Tip-down seats can also be utilized for some or all seats to increase the space available for both seated and standing passengers depending on needs and preferences. Stanchion poles and grab-straps can be provided for passenger stability. In urban transit applications, most passengers will prefer to stand, especially for short rides. The width of aisles can be adapted to an owner's preference and to meet the required access criteria. The seating layout can be specified by a system owner during the design phase.

See the following page for examples of seating configurations.

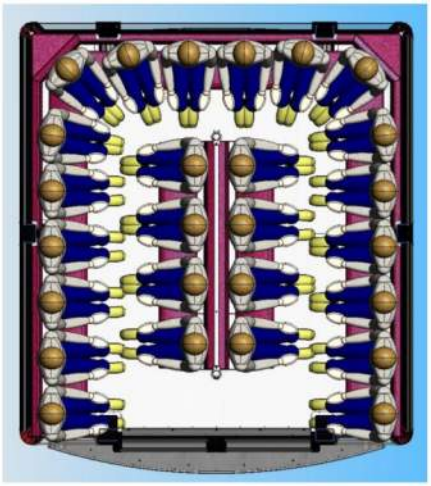

Image 30 – Maximum Seated Passenger Configuration (26 seats)

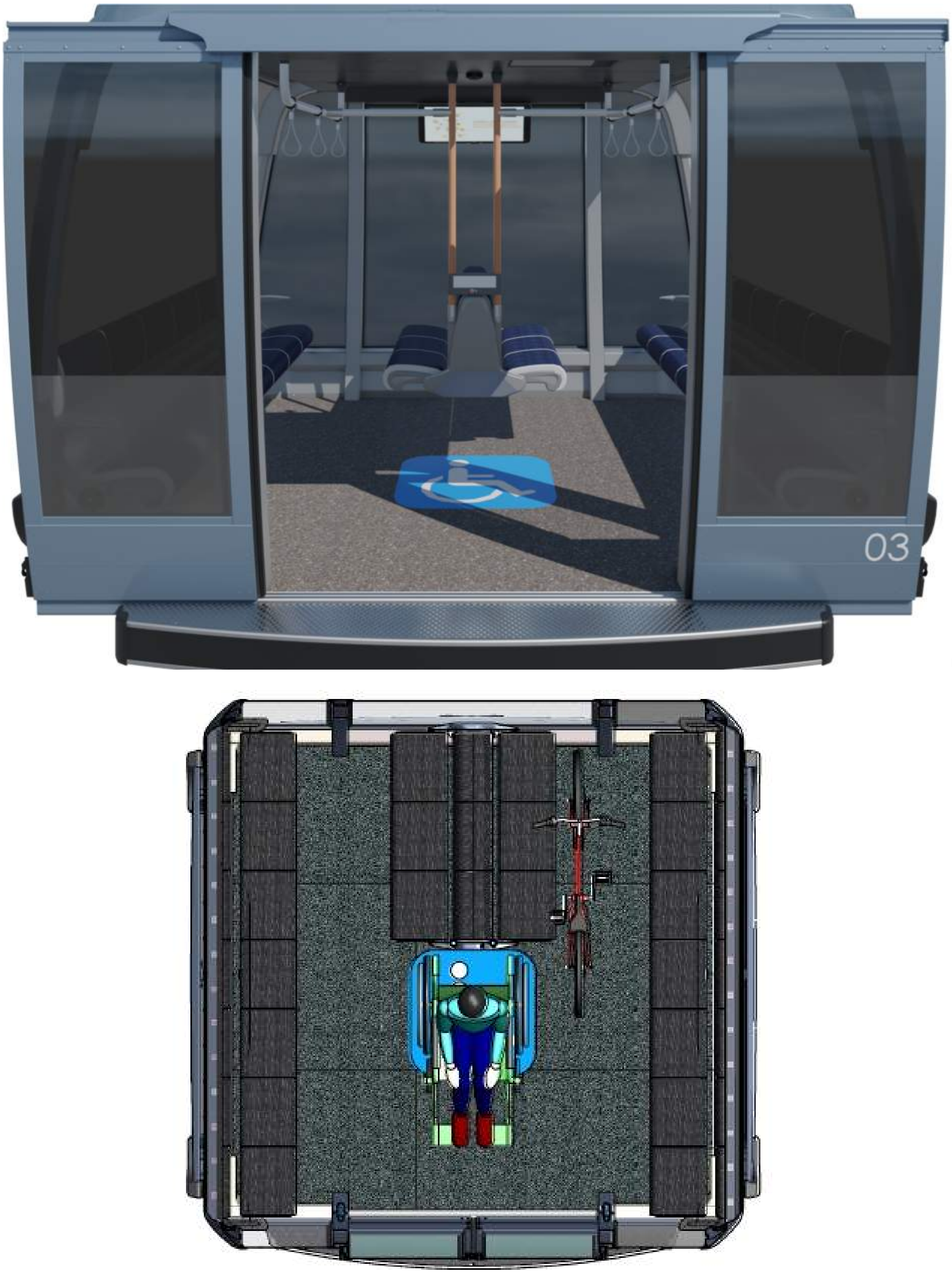

Image 31 – Hybrid Seating Configuration

Interior Lighting: 3S Gondola systems that operate after daylight hours incorporate interior lighting that meets the appropriate standards. Floor lighting is typically used to create a safe space in which to move, but not create a reflection on the interior of the cabin windows.

Image 32 – Examples of Interior Lighting

Signage and Multi-Media: 3S Gondola cabins can be outfitted with fixed signage, replaceable signage media and even digital displays. Fixed signage may include system maps or safety information while replaceable sign media may be used for advertising or event notification. Multi-Media displays can similarly be used to convey this same information as a set of revolving still images or even show videos and current weather or news information.

Image 33 – Example of Interior Multi-Media

Cabin Monitoring:

3S Gondola cabins can include closed-circuit video that can be monitored by the operations staff to promote safety and security. Cameras can be visible to passengers as a deterrent or hidden. Cabins can also have call buttons and intercoms that allow passengers to contact the operations staff.

Image 34 – In-Cabins Call-Button and Intercom

Image 35 – Operator Screen of In-Cabin Video

Image 36 – In-Cabin Camera

Wi-Fi Communications:	3S Gondola systems can provide Wi-Fi to passengers. This is typically implemented by installing Wi-Fi hot spots on towers to provide service to the entire route.
Ventilation:	3S Gondola cabins typically include ventilation systems that either utilize the velocity of the cabins to move fresh air though the cabins or fans to move outside air into the cabins. Cabins typically have passive vents on the opposite side of the cabin to allow air to exit. These systems can be adjusted seasonally to operate when needed and otherwise remain inactive. The inclusion of fans requires in-cabin power (see below). For short travel times, ventilation is usually sufficient for warm seasons. In cold weather, simply being enclosed in a cabin often creates a reasonable environment. Passengers typically must travel at least short distances in the elements to arrive at a gondola station and are therefore both dressed and acclimated to the conditions.
Heating:	In some installations, 3S Gondola Cabins have been implemented with heating systems. These systems can blow warm air or heat seats. Adding heat to cabins requires significant power which can be a limiting factor (see below).
Air Conditioning:	Some gondola systems have provided air conditioning for the cabins. In moderate climates, systems with short ride times typically use only passive ventilation. Air conditioning also requires significant power which can be difficult to achieve (see below).

Note: Instead of installing heating or air conditioning in cabins, some systems have equipment in the stations to blow conditioned air into the cabins prior to passengers boarding. This typically creates a comfortable ride for short to medium duration trips.

In-Cabin Power:

3S Gondola cabins are technically capable of providing limited power to support ventilation, heating, air conditioning and convenience power (USB or wall outlets). The addition of power in the cabins can be achieved by a number of sources as described below. For systems with short to medium trip times, the added complexity of these systems comes without significant upside. Further, the systems described below can add significant weight to cabins and potentially reduce the passenger carrying capacity as the maximum weight per cabin is a fixed value.

Batteries

Batteries can be added to cabins and placed in the floor, on the roof or under fixed seats. A significant amount of battery power will add a considerable amount of weight. Batteries must be charged while the cabins are off-line and in the cabin storage area. This can occur at night when the system is out of operation, but the fact that the batteries must last a full operational shift make the power they can provide limited. Batteries also have a finite working life and must be replaced occasionally.

Super Capacitors

Super capacitors can be similarly installed in cabins to provide power and have the benefit of faster charging times. It is technically feasible, though challenging, to charge super capacitors while the cabins cycle through the stations. Given the short duration a cabin is in a station traveling at slow speed, the power transfer must happen very quickly. Super capacitors are also heavy and have the potential to reduce passenger capacity.

Solar PV Panels

Photovoltaic solar panels have been installed on gondola cabins to provide small amounts of power for interior wall outlets or USB charging ports. Batteries are generally also required to store the solar power.

Image 37 – Solar Panels Mounted to Cabin Roof

Carriage Power Generation

It is possible to generate power through the interaction of the cabin carriage and the track ropes. A small generator is incorporated in the grip assembly and turned by one of the wheels through contact with the stationary track rope. This system adds complexity to the cabin which requires additional maintenance. Since there are a significant number of cabins on a system, any added cabin maintenance can create sufficient work for one or two full-time staff.

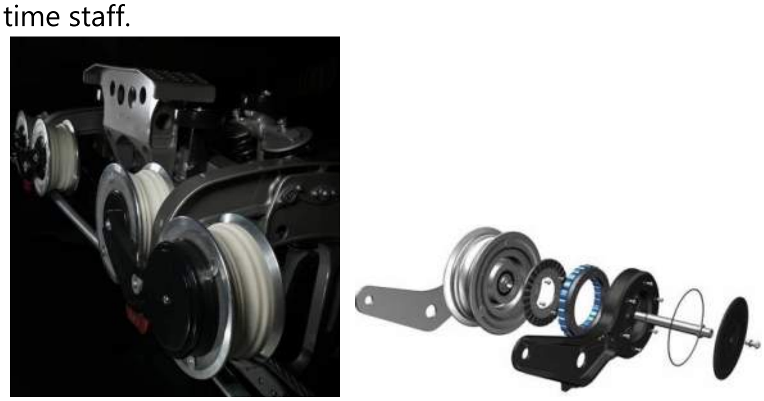

Image 38 – Carriage Power Generation

Gondolas and Privacy

In an urban environment, transit systems must often navigate the available open space. This often brings a transit system in close proximity to existing structures and other properties. Aerial gondola systems are not unique in this fact, but the nature of the systems creates some additional advantages and challenges. The ability of an aerial ropeway system to fly over challenging terrain and infrastructure is a net positive, but owing to their significant height, screening the system is impractical and viewsheds are more impacted. People are typically used to seeing buses and light rail vehicles traveling through a city. The simple fact that a gondola system is different and new may create additional concerns, whether warranted or not. There is often a period of time required for such a system to become accepted in a community. One example of this situation is the Roosevelt Island Tramway. It was originally built as a temporary measure to provide easy access from the Island to Manhattan while the subway below the East River was built. The system met some initial resistance, but ultimately gained favor. After the subway was completed, the tramway removal was rejected by the community as it was the preferred transit technology.

Some of the concerns of property owners and occupants in the vicinity of an aerial gondola are related to gondola passengers either seeing into their buildings through windows and skylights or seeing into a fenced piece of property that is otherwise screened from viewing. There are several mitigation measures that can address these issues:

Profile Design: One advantage of an aerial ropeway system is that the elevation the cabins travel can vary along the route fairly easily. In some instances increasing the elevation of the system can mitigate privacy concerns. For example, raising a system can prevent the gondola cabins from passing by a building's windows. Alternatively, lowering an alignment may also be beneficial if it reduces the perception of property owners that gondola passengers can see into their spaces.

Image 39 – Gondola Traveling Intentionally High Past a Property

Window Louvers: The simple addition of louvers on gondola windows can inhibit gondola passengers from seeing out of cabins at specific angles while allowing passengers to see out of cabins at other angles.

Tinting Windows: Technologically advanced glass can be installed for cabin windows. This system is activated automatically and makes windows opaque by introducing an electric current in the material. With this method, the windows can be selectively tinted at various locations along a route where sensitive areas exist. While effective, this system adds cost to the project.

Image 40 – Window with Tinting Glass

3S Gondola System Noise Sources

3S Gondola Systems are typically much quieter than conventional transit systems like light rail or busses. Due to the vehicles being propelled by a cable, the majority of the machinery and noise sources are concentrated at station locations. Along the route, cabins do not emit noise and at tower locations only minimal sound is produced as the cabins roll over the tower tops. At stations, the majority of the noise created is due to passengers, air conditioning equipment and ancillary equipment like escalators. The sound produced at gondola stations is typically considerably less than the sound produced at bus stops and SkyTrain stations as those transit vehicles produce significant noise from braking systems and engine noise.

The following diagram identifies typical noise sources and estimated sound values:

Image 41 – Sources of 3S Gondola Sound

The following common sources of sound have been provided for reference:

Quiet Home – 35 dB
Quiet Library – 40 dB
Office – 45 dB
Soft Music – 50 dB
Dishwasher – 55 dB
Normal Conversation – 60 dB
Washing Machine – 70 dB
Lawnmower – 75 dB
Noisy Restaurant – 85 dB
Car Horn – 100 dB

The following chart estimates the sound intensity at varying distances from a typical 3S Gondola tower with an example height of 110 m. Comparison sources have been provided for reference.

Distance from Tower Base	Sound Intensity
25 m	50 dB (soft music)
175 m	45 dB (office)
340 m	40 dB (library)
625 m	35 dB (quiet home)

Note: The above values have been provided to give a general understanding of sound intensity from a variety of gondola sources. The actual magnitude of sound from these sources is highly variable and dependent on the design of the gondola system and the station enclosures.   At distances greater than specified, the sound intensity decreases by 6 dB for a doubling of the distance.

3S Gondola System Safety & Reliability

3S Gondola Systems are a safe form of transit. The fact that gondola systems travel through the air, reduces their interactions with automobiles and other impediments that can hamper other ground-based transportation technologies. Since an aerial transit system travels above ground level, the reliability of the system is obviously very important. Every transit system consists of electrical and mechanical equipment which can malfunction from time to time. A timely return to service depends on:

1) Safety – no major equipment failure, which is mitigated by regular inspections and servicing, for example; and
2) Timing – a timely return to service is a priority, supported by temporary contingency plans for transit (ie bus bridge) while inspections and service take place, for example.

As such, there are a number of features of the 3S Gondola technology that ensure both safety and a prompt return to service.

Proper Maintenance: The first principle of reliable transit operation is a program of well maintained equipment. Maintaining equipment properly according to a defined schedule makes component breakdown unlikely.

Redundant Machinery: 3S Gondola Systems can be implemented with suitable redundant machinery that under only the rarest of circumstances will a delay in a return to service be likely. Some examples include backup motors that can be quickly engaged and backup electrical power in case of an outage.

Integrated Rescue: Through an approach termed "Integrated Rescue", a 3S Gondola system can be one of the most reliable transit technologies in the world. This concept is named as such because it avoids the need for an evacuation or "rescue". It accomplishes superior reliability through careful system design in which a detailed hazard analysis identifies potential points of failure and mitigates the likelihood of a failure. This basically means planning a work-around for any piece of failed equipment such that passengers can be transported in cabins to stations under any circumstance.

Image 42 – Backup Drive

Image 43 – Backup Power Generators

System Evacuation:

The likelihood of a technologically advanced 3S Gondola System failing to operate under its own power is so remote that most systems will never experience a system evacuation. Aerial ropeway systems are strictly regulated and one component of the required operation plan is evacuation. What this typically means for the 3S Gondola technology is the integration of one or more rescue vehicles. Systems are designed so that each point along the route can be reached with a rescue vehicle. A rescue vehicle can be designed to do one of two things:

1. Collect passengers from each cabin and take the passengers to a station or
2. Connect to each cabin and transport the cabins to a station to unload.

Ticketing and Access Control

3S Gondola stations can utilize similar technology as other transit systems for ticketing and access control. Ticketing can be pay per ride or through a pass system. Tickets can be purchased through an electronic vending system or from a cashier. The ticketing system can be independent or integrated with a transit system. Within a station, access control can be provided by turnstiles, attendant verification or through an honor-system with occasional verification by authorities.

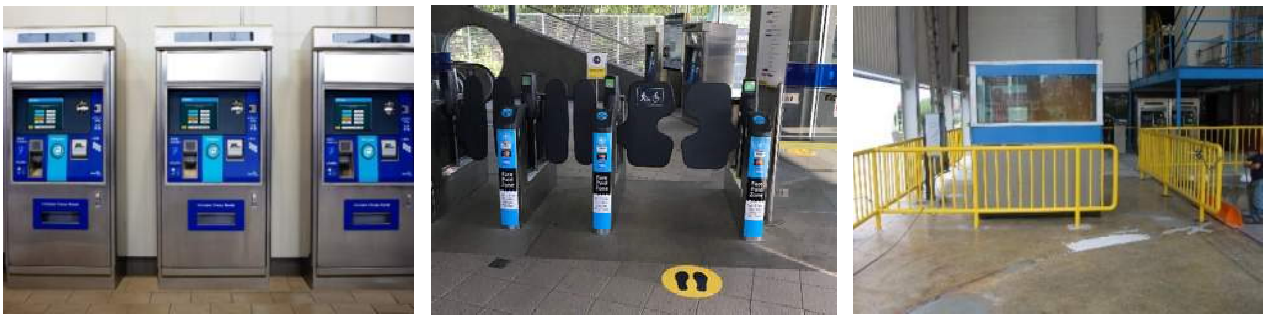

Image 44 – Examples of Access Control and Ticketing

3S Gondola stations can be constructed to easily accommodate passengers traveling by bicycle. Passengers dismount and enter the station by ramp, elevator or stair. It is often left to the passenger to determine the most appropriate route. Within the station additional features can be implemented to improve bike access.

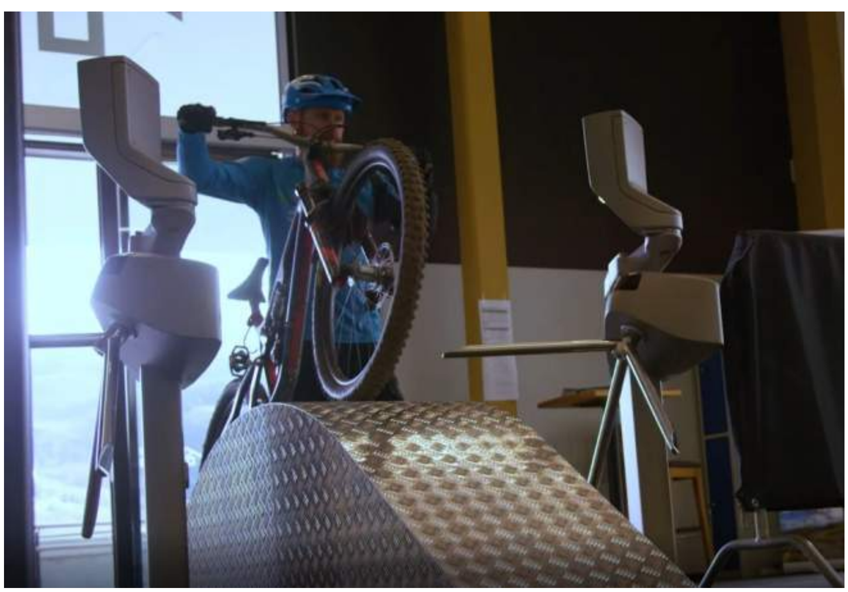

Image 45 – Examples of Bicycle Amenities

3S Gondola Cabin Storage, Operations & Maintenance

A 3S Gondola system is a complex system and an investment. For safe and reliable operations, sufficient staff and suitable facilities are required:

Operations:	3S Gondola Systems operate automatically. Operations staff often utilize video and/or a window to view the loading platform. Many systems also utilize additional staff on the loading platforms to observe and aid passenger loading and unloading. All staff positions have controls to slow and stop the system should anything occur.
Routine Maintenance:	3S Gondola Systems require frequent and routine maintenance to provide safe and reliable service. Each system requires a maintenance facility. Maintenance facilities are typically located at a station. Most maintenance occurs where the equipment resides. For example, tower machinery is frequently lubricated and station equipment is often maintained in place. Some equipment is removed and taken to the maintenance area. Cabins are maintained in a specific area of the maintenance area. Typically one or more spare cabins are provided such that a full number of cabins remain on line even when cabins are receiving maintenance. Most system maintenance occurs at night or when the system is scheduled to be out of operation. At scheduled intervals, major maintenance is also required that will impact system operations. This maintenance can be planned at convenient times where ridership is expected to be low.
Cabin Storage:	3S Gondola Systems typically include an indoor storage area for the gondola cabins. When not in operation, cabins are typically removed from the line automatically and stored to reduce exposure and the opportunity for vandalism. The cabin storage area is commonly collocated with the maintenance facility or a station.

Image 46 – Operator Control Panel

Image 47 – Maintenance Area

Image 48 – Cabin Storage Area

Construction of a 3S Gondola System

There are a number of things to consider when examining the local labor and economic impacts of the construction of a 3S Gondola system:

System Equipment:	Most gondola electro-mechanical components are produced by the system manufacturer or sourced from specific vendors with whom the gondola supplier has relationships. This ensures reliable installation and operation. There is little opportunity to source the necessary equipment from a Canadian source.
Cabins:	All 3S Gondola cabins are manufactured in Europe. There is no opportunity to produce these specialized products in Canada.
Structural Steel:	Structural steel is typically the preferred material for tower structures and a portion of the station infrastructure. These components are similar to other structures and can typically be fabricated locally if a project owner stipulates this requirement. The project costs could increase if the structural steel components were produced in Canada as opposed to other areas of the world, even considering transportation costs.
Foundations:	The materials and contractor labor required to construct the tower and station foundations is anticipated to be sourced locally in Canada.
Stations:	The materials and contractor labor required to construct the station structures is anticipated to be sourced locally in Canada. Additionally, the infrastructure included in the stations (vertical circulation elements, HVAC equipment, lighting, etc.) can all be sourced locally as appropriate.

It is estimated that the implementation of a 1-Section 3S Gondola system would employ approximately 50 local construction workers over the period of one year in addition to the workers required to construct the station buildings. A 2-section system would require approximately two times as many local construction workers.