APPENDIX E

Draft Aerial Transit Initial Feasibility Study

Draft Aerial Transit Concepts Initial Feasibility Study

Little Cottonwood Canyon Environmental Impact Statement S.R. 210 - Wasatch Boulevard to Alta

Lead agency:
Utah Department of Transportation

April 3, 2020

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Acronyms and Abbreviations

1S	one-cable gondola system
2S	two-cable gondola system
3S	three-cable gondola system
ATS	aerial transit system
EIS	Environmental Impact Statement
fps	feet per second
I-215	Interstate 215
mph	miles per hour
NA	not applicable
O&M	operation and maintenance (cost)
S.R.	state route
SANDAG	San Diego Association of Governments
UDOT	Utah Department of Transportation
USDA	United States Department of Agriculture
UTA	Utah Transit Authority

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1.0 Introduction

The purpose of this report is to summarize the Utah Department of Transportation's (UDOT) evaluation and other considerations regarding constructing and operating an aerial transit system (ATS; also called a cableway, ropeway, or tramway) as part of the S.R. 210 Project. This report provides information that UDOT will use during the alternatives development and screening process for the Little Cottonwood Canyon Environmental Impact Statement (EIS), which will evaluate how well the ATS concepts described in this report would satisfy the purpose of the Project.

What is the purpose of this report?

The purpose of this report is to summarize UDOT's evaluation of and recommendations regarding the feasibility of constructing and operating an aerial transit system as part of the Little Cottonwood Canyon Project.

The goal of this report is to define the ATS technology that is most feasible for the needs of Little Cottonwood Canyon. The information in this report will be used to compare the most feasible ATS concepts with other non-ATS concepts considered to address the purpose of the project.

1.1 Aerial Transit Systems

Modern ATSs were developed to move skiers to the tops of ski slopes. ATSs can consist of permanently fixed or detachable cabins that are attached to steel cables and that travel above ground. ATS technologies include aerial tramways, Funifors, Funitels, and gondolas. See Section 2.0, Types of Aerial Transit Systems, for descriptions of these different technologies. The popularity of these systems as a form of urban mass transit is growing throughout the world because they can reliably move a substantial number of people between destinations.

The benefits of ATSs include reduced right-of way needs in densely developed areas compared to other types of transit that use an exclusive right-of-way, the ability to navigate difficult terrain (climb steep hills or span waterways), and lower costs compared to some other types of transit (commuter rail or light rail for example). The limitations of ATSs include a reduced number of stations compared to other types of transit, the need for straight alignment segments, relatively low speeds, and a limited ability to add capacity once an ATS is constructed. See Section 4.0, General Considerations for Implementing a 3S Gondola System, for more information regarding the unique engineering and operational considerations of the recommended type of ATS.

1.2 Description of the Study Area

Little Cottonwood Canyon is in the Uinta-Wasatch-Cache National Forest, which is on the eastern edge of the Salt Lake City metropolitan area located in Salt Lake County. Salt Lake County has a population of about 1.12 million. The canyon is home to two ski resorts, Alta and Snowbird, and includes parts of two National Wilderness Areas: Twin Peaks Wilderness to the north and Lone Peak Wilderness to the south. Winter recreation activities include skiing at the resorts, backcountry skiing, snowshoeing, and ice climbing. In the summer, the resorts offer abundant recreation opportunities, and land administered by the U.S. Department of Agriculture (USDA) Forest Service is used extensively for hiking, cycling, rock climbing, fishing, camping, and picnicking.

The transportation needs assessment study area used for the Little Cottonwood Canyon Project extends along State Route (S.R.) 210 from its intersection with S.R. 190/Fort Union Boulevard in Cottonwood Heights, Utah, to its terminus in the town of Alta, Utah, and includes the Bypass Road. UDOT developed the study area to include an area that is influenced by the transportation operations in Little Cottonwood Canyon and to provide logical termini for the project. Traffic south of the S.R. 190/Fort Union Boulevard intersection is mostly related to trips into and out of Little Cottonwood Canyon and commuter traffic on Wasatch Boulevard.

Through the transportation needs assessment study area, S.R. 210 is designated with different street names. For clarity in the EIS process, the following segments of S.R. 210 use the following naming conventions (shown in Figure 1):

- **Wasatch Boulevard** – S.R. 210 from about Fort Union Boulevard to North Little Cottonwood Road
- **North Little Cottonwood Road** – S.R. 210 from Wasatch Boulevard to the intersection with S.R. 209
- **Little Cottonwood Canyon Road** – S.R. 210 from the intersection of North Little Cottonwood Road and S.R. 209 through the town of Alta, including the Bypass Road, up to but not including Albion Basin Road

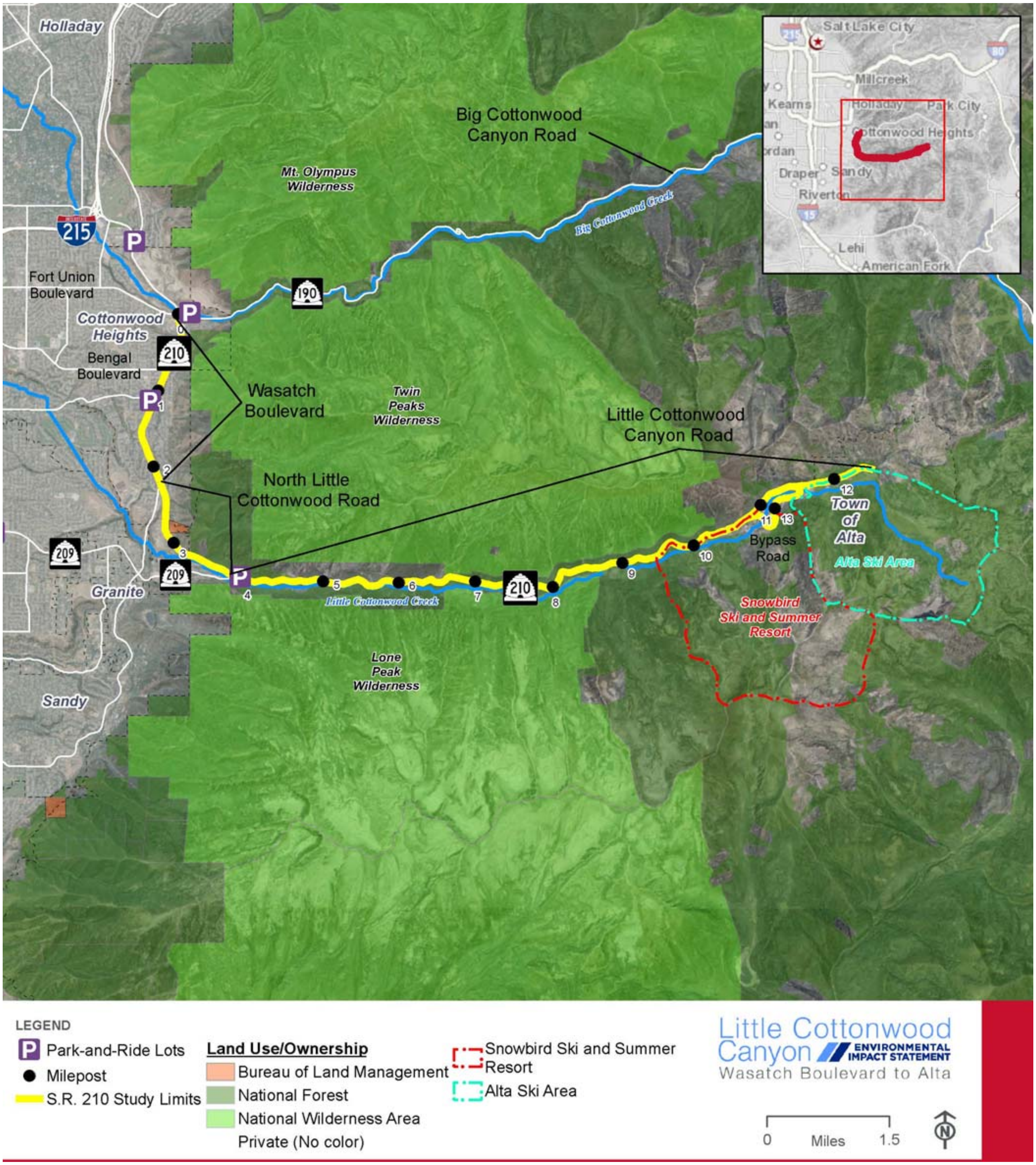
In this report, ATSs are being proposed mainly to address heavy skier use in winter and the related traffic congestion on North Little Cottonwood Road and Little Cottonwood Canyon Road. For this ATS feasibility analysis only, the study area also includes S.R. 209 (9400 South) in Sandy, Utah.

1.3 Previous Analysis

Several previous studies have analyzed the current and future transportation needs for Big and Little Cottonwood Canyons. In 2012, Salt Lake County and its study partners—UDOT, the Utah Transit Authority (UTA), Salt Lake City, the Wasatch Front Regional Council, and the USDA Forest Service—developed a range of short- and long-term transportation solutions. The *Mountain Transportation Study* (Fehr and Peers 2012) recommended evaluating the range of alternatives in an EIS.

In the years before the current EIS process was initiated, UDOT, UTA, and other agencies and planning organizations conducted studies of congestion, parking, transit use, and avalanche impacts in Little Cottonwood Canyon and on S.R. 210. Numerous studies were conducted as part of a process known as the Mountain Accord. The Mountain Accord developed a plan for preserving the central Wasatch Mountains (which include Little Cottonwood Canyon) including short- and long-term transportation options. Both of these studies (the *Mountain Transportation Study* and the Mountain Accord) identified ATSs as one of many potential transportation concepts that should be explored in greater detail under an EIS framework.

Figure 1. Transportation Needs Assessment Study Area for the Little Cottonwood Canyon EIS



2.0 Types of Aerial Transit Systems

There are several different types of ATS, each of which has unique characteristics in terms of the mechanics of its cabling, its capacity, its speed, and the maximum practical spacing of its towers. The feasibility of each type depends on the specific application for which it is used. Section 2.0 describes four types of ATS: aerial tramways, Funifors, Funitels, and gondolas.

In this report, the term *terminal station* refers to the first and last stations on a passenger's route. Passengers board and disembark the ATS cabins at the terminal stations. The *base station* is the terminal station at the bottom of the canyon, and a *destination station* is a terminal station at the top of the canyon. An ATS can also include *angle stations*, which are needed to adjust the horizontal direction of the cabin; passengers remain in the cabin as it passes through an angle station.

2.1 Aerial Tramways

With aerial tramways, cabins are permanently fixed to the cable system that hauls the cabins. This means that a tramway cabin must shuttle back and forth between origin and destination points using the same cable. Typically, two cabins are operationally connected: as one cabin moves uphill, the other moves downhill. Snowbird Resort's tram is an example.

Photo credit: Georgeclerk

The capacity (people per hour per direction) of an aerial tramway is a function of the cabin capacity (up to 150 to 200 people per cabin), the travel speed, and the distance between the origin and destination. These systems have high speeds and good capacity for short distances. However, because cabins are fixed to the haul cable and the cabin shuttles back and forth, one-way capacity becomes limited for long distances. The maximum spacing of terminal stations for tramways was not determined for this analysis. Several separate segments might be required in the canyon.

Aerial tramways have speeds of about 22 miles per hour (mph)[1,2] If aerial tramways are operationally feasible, the total travel time at about 22 mph from the mouth of Little Cottonwood Canyon to a terminal station between Snowbird and Alta (a total distance of 8 miles) would be about 30 minutes. When loading and unloading times are included, the tramway system could make just one round trip per hour per cabin. Assuming that two tramway cabins are implemented, the total capacity would be about 300 to 400 people per hour per direction. Because of its limited capacity, this type of ATS is not feasible for Little Cottonwood Canyon.

1 http://www.gobytram.com/about

2 https://liftblog.com/2016/10/28/at-45-years-snowbirds-tram-still-soars

2.2 Funifors

Photo credit: Doppelmayr

Funifors are similar to aerial tramways in that the cabins are fixed to a haul cable. Funifors ride on two guide cables for additional stability during high winds. Like tramways, Funifors travel from origin to destination and back. Unlike tramways, the haul rope and cabins of this system can operate independently with separate drives. Funifors have speeds of about 22 mph. The capacity is about 60 passengers per cabin.[3]

Like tramways, Funifors have operational limitations for large distances between terminal stations. At 22 mph, and assuming an 8-mile route and including loading and unloading times, a Funifor system would make one round trip per hour per cabin. Assuming that two 60-passenger cabins are implemented, the total capacity would be about 120 people per hour. Because of its limited capacity, this type of ATS is not feasible to address the mobility needs of Little Cottonwood Canyon.

2.3 Funitels

Photo credit: Jarin047

Funitels use detachable cabins that attach to two haul cables. The haul cables (which is actually one continuous, looped cable) circulate between terminal stations so that the cables are paired, and the same cable pair transitions from up to down so that the weight of the cabins heading downhill assists with lifting cabins uphill. Cabins are slowed down through the terminal stations for passenger loading and unloading. Therefore, different cabin propulsion systems are used within the terminal stations. Funitels have speeds of about 13 mph.[4] Cabins are typically sized for 18 (seated) to 24 (standing) people.

Because the cabins circulate between terminal stations and do not run back and forth like aerial tramways or Funifors, a Funitel system's cabins arrive more frequently, and the total capacity is about 3,200 to 4,000 people per hour. Funitels are stable in higher winds. According to the *Mountain Transportation Study* (Fehr and Peers 2012), Funitels are mechanically complex and have long evacuation times. Funitels are more energy-intensive and need more maintenance, and are therefore more expensive to operate and maintain (CH2M 2018). Funitels also require shorter tower spacing than do three-cable gondolas, which are described in Section 2.4.3, Tri-cable Gondola (3S). Because of these reasons, UDOT selected gondolas over Funitels for more detailed analysis in this initial feasibility report.

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3 https://www.doppelmayr.com/en/products/funifor/

4 https://www.doppelmayr.com/en/products/funitel/

2.4 Gondolas

Gondola cabins have detachable grips. Cabins are detached and slowed at the terminal stations for loading and unloading passengers. A main haul cable circulates between two stations. Like for Funitels, these stations have their own propulsion systems that slow the cabins for unloading and loading or, in the case of angle stations, for changing direction, and then gradually increase the speed of the cabin to match the speed of the haul cables. The main differences between the gondola systems are their speeds, wind stability, and maximum feasible tower spacing. UDOT evaluated three types of gondolas for the EIS—mono-cable (1S), bi-cable (2S), and tri-cable (3S)—which are described below.

Why are gondola types abbreviated 1S, 2S, and 3S?

These abbreviations come from the German word *Seil*, which means "cable," and refer to the number of cables used to propel and support the gondola cabins.

2.4.1 Mono-cable Gondola (1S)

Mono-cable gondolas use a single cable for both propulsion and support. This means that the cable that pulls the cabins is also the cable that supports the cabins. Compared to other gondola systems, 1S gondolas have smaller towers, and the towers are typically spaced shorter distances apart (up to about 2,300 feet) to support the weight of the cable and cabins. They operate at maximum speeds of about 11 mph (Fehr and Peers 2012). The travel time for the 8-mile trip from the mouth of the canyon to Alta would be about 44 minutes.


Photo credit: FilippoBacci

Because the gondolas are supported by just one cable, mono-cable systems are most susceptible to being shut down during high winds.

2.4.2 Bi-cable Gondola (2S)

Another type of gondola is the bi-cable gondola. In addition to the main haul cable, a bi-cable gondola has one stationary cable that helps support the cabins. Because of the added stability provided by the second cable, 2S gondolas can operate slightly faster (5 to 6 mph) than 1S gondolas. The maximum distance between towers can be longer for 2S gondolas compared to 1S gondolas. At a speed of 15 mph, the total travel time for the 8-mile trip from the mouth of the canyon to Alta would be about 32 minutes.


Photo credit: Magnus Manske

2.4.3 Tri-cable Gondola (3S)

A third type of gondola is a tri-cable gondola system. This system has two fixed-support cables and one circulating haul cable connected to the cabins. The main benefits of 3S gondolas are faster speeds, the potential to increase the tower spacing up to about 9,000 feet,[5] a greater number of passengers per cabin (up to 35 per cabin, standing), a high capacity (up to about 5,000 people per hour per direction), and greater wind stability than 1S and 2S gondolas. At 17 mph, the total travel time for the 8-mile trip from the mouth of the canyon to Alta would be about 27 minutes.

Photo credit: clickflashphotos

2.5 Other Systems

During the scoping period for the EIS, UDOT received several comments regarding ATSs and the infrastructure required to make these systems useful. (For more information, see Section 4.3, Base Station Parking Considerations). One comment asked UDOT to evaluate a transit concept that is a hybrid bus-ATS.

What is scoping?

Scoping is an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action.

The comment first stated that a multilevel parking garage at the mouth of Little Cottonwood Canyon was not feasible and would be met with strong opposition because of concerns with neighborhood traffic congestion. The commenter also stated that a parking structure located away from the mouth of the canyon would require an ATS alignment that strung the cable over large residential areas, which would also be met with strong opposition. Therefore, the commenter asked UDOT to evaluate a hybrid bus-ATS, which can be generally described as follows:

- Build a large parking structure away from the mouth of the canyon, build a bus-ATS base station at the mouth of the canyon, and build an ATS in the canyon.
- In the morning, passengers would board a large ATS cabin at the parking structure. The cabin would be attached to an over-the-road, electronically powered “transporter” vehicle that would be used to move the loaded cabin to the base station. The transporter could eventually be an autonomous vehicle. This over-the-road cabin would function as a bus to transport passengers from the parking structure to the base station.
- At the base station, the cabin would be detached from the transporter’s chassis, the same cabin would be attached to the ATS’s cable system, and passengers would continue up the canyon via the ATS.
- The transporter would then pick up the empty cabin and return it to the parking structure, where more people would board and the cycle would continue.
- In the evening, the process would be reversed, with passengers coming down the canyon via the ATS and the loaded cabins being moved via the transporter vehicle from the base station to the parking structure.

5 https://www.leitner-ropeways.com/fileadmin/user_upload/Tricable_gondola_lifts.pdf

The main benefit of this proposal is that it could eliminate the need for passengers to change transit modes. They would remain in the same cabin from when they boarded at the parking structure to their destination. However, UDOT is not aware that a similar technology exists. The size, cabin capacity, and weight of each loaded cabin was not provided by the commenter. UDOT cannot determine the system's mechanical needs (cable strength, detaching mechanisms, and power) and operational performance (number of people per hour). Because no similar system exists to prove the concept, it is not considered reasonable for detailed analysis in the EIS.

3.0 Selection of ATS Technology

Because of their travel speed and hourly capacity, gondola systems are the most feasible ATS for Little Cottonwood Canyon (for more information, see Section 2.4, Gondolas). Table 1 summarizes the different parameters for the three gondola systems (1S, 2S, and 3S) that were evaluated in this report.

Table 1. Comparison of Gondola Systems

Parameter	Mono-cable (1S)[a]	Bi-cable (2S)	Tri-cable (3S)[a]
Capacity per cabin (number of people, maximum)	8 to 15	8 to 17	20 to 35
Travel speed (mph)	9 to 11	15 to 16	16 to 18
Operational wind speeds (mph)	37	43	68
Maximum capacity (approximate number of people per hour per direction)[b]	3,000	4,000	5,000
Approximate maximum tower spacing (feet)	2,300	3,000	9,000
Travel Times[c]			
Mouth of canyon to Snowbird (minutes to travel 6.5 miles)	35	26	23
Snowbird to Alta (minutes to travel 1.5 miles)	8	6	4
Total (minutes to travel 8 miles)	**44**	**32**	**27**

[a] Source: Fehr and Peers 2012

[b] The maximum hourly capacities are based on literature reviews and do not necessarily represent gondola capacity needed in the Little Cottonwood Canyon setting.

[c] Travel times are calculated based on travel speeds (1S: 11 mph; 2S: 15 mph; 3S: 17 mph) and the distance between the base and terminal stations.

The mono-cable (1S) system was eliminated from consideration because it would have the lowest per-cabin passenger capacity, would have the slowest travel speeds and times, and would require the most towers. Both the bi-cable (2S) and tri-cable (3S) systems would provide reliable and safe transportation. However, the 3S system would provide some specific advantages including greater person-capacity, more cabin options, faster speeds, and greater potential tower spacing. The greater tower spacing would offer the most flexibility to help avoid sensitive environmental areas.

Although the smaller 2S towers could have less visual impacts, UDOT would likely need to build more towers. Additionally, one disadvantage of the 2S system is that it does not have "slack carriers." Slack carriers in the 3S system are pieces of equipment that are connected to the two support cables and that support the haul cable at all times. These slack carriers are shown on the left side of the photograph in Section 2.4.3, Tri-cable Gondola (3S). In a 2S system, the cabins themselves support the haul cable between the towers. Whenever the cabins are removed from the haul cable (for maintenance), the haul cable sags low. Therefore, a 2S system requires shorter distances between towers to keep the haul cable from touching the ground when the cabins are removed, and this could increase the number of towers required compared to a 3S system.

Because it would have the greatest maximum passenger capacity, the fastest travel times, the greatest operational benefits (most stability in high winds), and the most opportunity to avoid environmental resources, the 3S-type gondola is the most feasible gondola system for Little Cottonwood Canyon. This selection of gondola technology matches the conclusion of previous studies (Fehr and Peers 2012; Mountain Accord 2017).

4.0 General Considerations for Implementing a 3S Gondola System

Section 4.0 presents the fundamental engineering and operational considerations for 3S gondola systems as well as considerations for parking at the base station. UDOT will compare ATSs to other concepts in a separate report or in the EIS.

4.1 Engineering Considerations

Section 4.1 describes some of the fundamental engineering considerations for 3S gondolas.

4.1.1 Stations

Gondolas work best as a point-to-point, or station-to-station, service. The cabins on the haul cable travel at 17 mph, or 25 feet per second (fps). In order to facilitate passenger loading and unloading, cabins are detached from the haul cables at terminal stations, are slowed gradually, and traverse the station platforms at slower speeds (about 1 fps). Therefore, adding intermediate stations would slow the overall travel time for the passengers who are traveling between the terminal stations.

Station spacing is a function of overall passenger capacity, the elevation gains, and the resulting power needs of the gondola. The *Mountain Transportation Study* (Fehr and Peers 2012) assumed 3,000 passengers per hour and assumed that two intermediate stations would be needed to turn corners and to supply the overall power needs of the conceptual system evaluated in that study. A conceptual 3S gondola alignment developed for UDOT by Leitner-Poma in 2018 assumed 4,000 passengers per hour and needed one intermediate angle station (see Section 4.1.2 below). This conceptual alignment placed the base station farther into the canyon.

Because some passengers would disembark at Snowbird, a smaller system (1S or 2S gondola, or another ATS) could be used from Snowbird to Alta. Passengers would be required to disembark from one ATS and board another. The details of the capacity and optimal system for the last segment of the trip are not included in this preliminary feasibility analysis.

4.1.2 Alignment

Gondolas require straight alignment segments between stations because gondolas can only turn at only very small angles. A maximum 7-degree deflection can be made at towers,[6] so angle stations are needed to turn sharper angles. Cabins are also detached and slowed as they approach an angle station. Cabins traverse through the angle station with a separate propulsion system (and therefore the angle station also needs to be powered), and then cabins are accelerated before being reconnected to the full-speed haul cable for the next alignment segment. The haul cable circulates between a base station and either a destination station or an angle station. Because passengers are not loading and unloading, the cabins might be able to pass through an angle station at speeds higher than 1 fps. Depending on the exact alignment in Little Cottonwood Canyon, one or two intermediate angle stations would be needed to move the cabins to the top of the canyon.

4.1.3 Towers

The tower spacing depends on the topography under the alignment, the elevation gain needed in each segment, and the vertical clearance required from obstacles (including snow and avalanche flows) below the alignment. The weights of the loaded gondola cabins and cables cause the line to sag between towers. To maintain vertical clearance requirements,[7] towers would be between 150 and 200 feet tall. Towers would be spaced between 2,000 and 3,500 feet apart on average. The towers could be placed outside avalanche flow paths, and multiple avalanche flow paths could potentially be spanned between towers.

4.1.4 Right-of-Way

Gondola stations and towers require a dedicated right-of-way or airspace. For the alignment segments between stations, an exclusive undeveloped airspace is preferred to avoid impacts to private property or the need for easements. The gondola airspace could feasibly be shared with the right-of-way of another public transportation facility or located over public land. However, if the airspace is within a wilderness area, special authorization from the USDA Forest Service would be needed.

The width of the airspace depends on the gondola manufacturer's equipment specifications, which define the required lateral spacing between cabins, as well as on a minimum outside clearance standard of 5 feet on each side of the gondola.[8] For example, a 40-foot-wide gondola would need a 50-foot-wide right-of-way. In addition, because of privacy concerns, UDOT expects heavy opposition from any private property owners living adjacent to the exclusive gondola airspace in residential areas.

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6 Notes from a meeting with UDOT and Doppelmayr, May 23, 2018.

7 Vertical clearance requirements are defined in American National Standard Institute B77.1-2017. The maximum height of an avalanche was not considered in the requirements for vertical clearance and approximate tower heights.

8 Horizontal spacing and airspace clearance requirements are defined in American National Standard Institute B77.1-2017. The final airspace requirement would need to include a swing distance, which is a function of tower spacing and was not considered when determining approximate right-of-way needs.

4.2 Operational Considerations

Section 4.2 describes some of the fundamental operational considerations of 3S gondolas.

4.2.1 Operational Capacity and Demand

As shown above in Table 1, Comparison of Gondola Systems, 3S gondolas have a maximum capacity of about 5,000 people per hour, or about 83 people per minute. Assuming a cabin capacity of 35 people per cabin, a cabin would have to arrive at a terminal station about every 25 seconds, on average. However, because of the long travel time (at least 27 minutes), some passengers would likely prefer to sit. The seated capacity is about 25 people per cabin. At a 25-to-30-second arrival frequency (or "headway"), the actual hourly capacity would be closer 3,000 to 4,000 people per hour. Top speeds would be about 17 to 18 mph. In addition, the time required for a cabin to traverse the terminal station platforms needs to take into account that passengers would be carrying ski or snowboard equipment and other supplies and might be walking with or carrying children.

The actual number of gondola users per hour might be different from the overall operational capacity. The actual anticipated demand, or ridership, depends on many factors. A demand analysis was outside the scope of the initial ATS evaluation presented in this report. UDOT expects the maximum hourly demand to occur during the winter months and on weekends and holidays when skiers and snowboarders are traveling to the resorts at the top of Little Cottonwood Canyon.

The expected peak period of travel demand on S.R. 210 in 2050, as measured by the number of vehicles currently using the road, is between 7:00 AM and 10:00 AM. The current free-flow capacity of the road is about 1,100 vehicles or fewer per hour, but this capacity analysis uses a peak-period demand number of about 1,555 vehicles per hour (which assumes an average busy ski weekend). Transportation analysts often look at the 30th-busiest hour on a road over the course of a year when determining the future travel demand on the road. For S.R. 210 in 2050, the 30th-busiest-hour roadway demand would be about 3,200 people per hour. A gondola could accommodate this level of *hourly* demand. However, the actual anticipated ridership of a gondola system, measured as the percentage of gondola users compared to the overall number of people accessing Little Cottonwood Canyon in the peak hour, was not evaluated in this report. In order to compare transit concepts (aerial transit, bus, and train) equally, UDOT assumed a similar peak-hour ridership of about 1,000 people for each.

What is travel demand?

Travel demand is the expected number of transportation trips in an area. Travel demand can be met by various modes of travel, such as automobile, bus, light rail, carpooling, bicycling, and ATS or a combination of modes.

4.2.2 Time Required for Shifting Transit Modes

Without a direct transit connection to the base station, the gondola system would require a large parking area where riders would park their personal vehicles (or disembark from another transit mode or rideshare), walk to the cabin loading platform, and board a cabin. These transfers take time. If parking is separated from the base station, additional walking time or some form of transit (people-mover or buses) would be needed to transport passengers from the parking area to the base station. When there is an additional shift in transit mode, riders would experience additional waiting and transfer times. These times are considered in

Section 5.0, Parking, Base Station, and Gondola Alignment Scenarios, which explores approximate travel times for different parking and base station scenarios.

4.2.3 Staffing

The "per-shift" staffing requirement for gondolas would be between 15 and 17 people.[9] The staffing requirements at the parking structure are likely 2 to 3 people. Staff positions include supervisors, operators, gondola platform attendants, parking attendants, administrative personnel, mechanics, and electricians.

4.2.4 Emergency Evaluation

The terminal stations and angle stations would need to be equipped with backup power to allow emergency evacuations. Diesel generators could be used to supply this power. An evacuation access would also be needed to each station. Therefore, it is preferable to locate stations closer to existing roads. Bridges would be needed if stations are sited on the south side of Little Cottonwood Creek. At a minimum, pedestrian access would be required at each tower, and each tower would be supplied with tools and equipment to fix a problem if it were to occur at a tower. Evacuation times would depend on the distance between each pair of stations.

4.2.5 Cooling and Heating

Gondola cabins are not typically air-conditioned. Heating and cooling all of the cabins would require high-voltage electrical power. Cabins could contain rechargeable batteries to power low-voltage lighting and intercom systems. However, providing the power needed to run heating or cooling units during transit would require installing high-voltage power lines with the gondola-carrying and hauling cables, which is not feasible.

4.3 Base Station Parking Considerations

Section 4.3 describes some of the fundamental considerations for parking at the gondola base station.

A large parking area would be needed near the base station. The required or anticipated ridership will inform the parking requirements, but these requirements were not considered in this report. This report presents general scenarios for parking locations because the locations of the parking area and base station are fundamental considerations for the feasibility of a gondola.

As described in Section 4.1, Engineering Considerations, straight alignment segments are required between stations. If the base station is located farther outside the canyon, it becomes more challenging to design a minimum number of straight segments because of the presence of residential neighborhoods. If intermediate stations (including possibly angle stations) are required, travel times between terminal stations would be greater because of the overall distance between the terminal stations and because cabins would need to decelerate to pass through the intermediate stations at a slower speed than the haul cable and then accelerate to match the speed of the haul cable.

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[9] Numbers for the Mountain Village Gondola in Telluride, Colorado, reported in the *Aerial Cable Transit Feasibility Study, Final Report* (Jacobs Engineering Group 2016).

Currently, the existing park-and-ride lots near the mouths of Big and Little Cottonwood Canyons are heavily used, especially during the winter. These lots operate at capacity most winter weekend days. There is parking away from the mouths of the canyons along the existing bus routes; however, these parking lots are heavily utilized during periods of peak winter demand. Because canyon users typically want the shortest travel time, transit riders tend to drive to the mouth of a canyon and take the ski bus up the canyon for the last segment of their trip. The same general principles would apply to gondola use.

Section 5.0 below presents various parking options and the resulting gondola alignment that would be needed. Several scenarios are presented to capture various options for accessing the base station from potential parking location.

5.0 Parking, Base Station, and Gondola Alignment Scenarios

Section 5.0 presents alternative parking lot and base station locations and describes the resulting gondola alignments. Several scenarios are presented in this section. Some scenarios include an expanded parking area and a base station at the same location. Other scenarios separate the parking area from the base station and assume that canyon users take a bus between the parking area and the base station. The different scenarios and options analyzed are:

- **Scenario 1** – Expanded parking and base station at the mouth of the canyon
- **Scenario 2** – Expanded parking and base station 1 mile from the mouth of the canyon
- **Scenario 3** – Expanded parking at a mobility hub at the gravel pit (near Wasatch Boulevard and Fort Union Boulevard)
    - **Scenario 3, Option A** – A complete gondola alignment from the gravel pit mobility hub to the mouth of the canyon and continuing to the resorts
    - **Scenario 3, Option B** – A bus trip from the gravel pit mobility hub to a base station at the mouth of the canyon
- **Scenario 4** – Expanded parking at a mobility hub near 9400 South (S.R. 209) and Highland Drive
    - **Scenario 4, Option A** – A complete gondola alignment from the 9400 South/Highland Drive mobility hub to the mouth of the canyon and continuing to the resorts
    - **Scenario 4, Option B** – A bus trip from the 9400 South/Highland Drive mobility hub to a base station at the mouth of the canyon

The remainder of Section 5.0 describes these scenarios in more detail, presents calculations of the approximate travel times, and presents approximate cost estimates. Also see Appendix A, Travel Time Calculations, for the travel time assumptions and calculations. See Appendix B, Aerial Transit Cost Estimates, for rough order-of-magnitude cost estimates.

5.1 Scenario 1 – Expanded Parking and Base Station at the Mouth of the Canyon

5.1.1 Parking Location and Gondola Alignment

There is an existing park-and-ride lot at the mouth of Little Cottonwood Canyon at the intersection of S.R. 210 and S.R. 209. The existing lot has about 160 spaces. An expanded parking lot at or near this location, which could accommodate the assumed high gondola ridership, would require a large, multilevel parking structure. In order to compare transit concepts (bus, gondola, and train) equally, UDOT assumed a similar peak-hour ridership of about 1,000 people and a peak daily ridership of about 5,200. This level of ridership for Little Cottonwood Canyon would require a parking structure of about 2,500 cars.

Some members of the public are opposed to expanding the parking lot at the base of Little Cottonwood Canyon because vehicle traffic during peak times causes traffic congestion in the area and restricts residents' ability to access their neighborhoods. A large parking structure at the base of the canyon would not help relieve congestion on S.R. 210 and S.R. 209 during peak arrival times. The mobility conditions with Scenario 1 would be similar to the current conditions with traffic trying to enter the canyon. The purpose of the Little Cottonwood Canyon Project is to reduce congestion-related access issues for residents who live at the base on the canyon (that is, not being able to enter or leave their neighborhoods during peak ski days) and to improve overall mobility.

This location for expanded parking and a base station has benefits with respect to the resulting gondola alignment. A 4-mile-long, straight gondola segment could begin at this base station location and extend to the area around Tanners Flat. At Tanners Flat, one angle station could be used to turn the alignment northeast and direct the alignment toward Snowbird. The second straight segment would run for about 2.5 miles from the angle station at Tanners Flat to Snowbird, and a third, 1½-mile segment would then connect Snowbird to Alta.

5.1.2 Travel Time

The approximate gondola travel time from a base station at the existing park-and-ride lot at the mouth of the canyon to Snowbird would be about 24 minutes (6.5 miles at 17 mph equals 23 minutes, plus 1 minute to pass through the angle station). This does not include the time it would take a gondola user to park their car (or shift from another transit mode or rideshare), walk to the base station, and wait to board the gondola cabin. For gondola riders continuing to Alta, an additional distance of about 1½ miles, the additional travel time would be about 9 minutes, which consists of a 3½-minute gondola transfer time plus a 5½-minute gondola ride.

What would be the total travel time to Snowbird and Alta with Scenario 1?

With Scenario 1, the total travel time would be about 44 minutes to Snowbird and about 54 minutes to Alta.

To calculate the total travel time for canyon users and to compare this travel time to that of other transportation modes (car, train, or bus), UDOT estimated the total travel time to reach the top of Little Cottonwood Canyon from a starting point at the intersection of Fort Union Boulevard and Wasatch Boulevard. This is the predominant route for users of the canyon. This scenario assumes an expanded parking area near the existing park-and-ride lot and assumes that gondola riders would access the parking area via automobile.

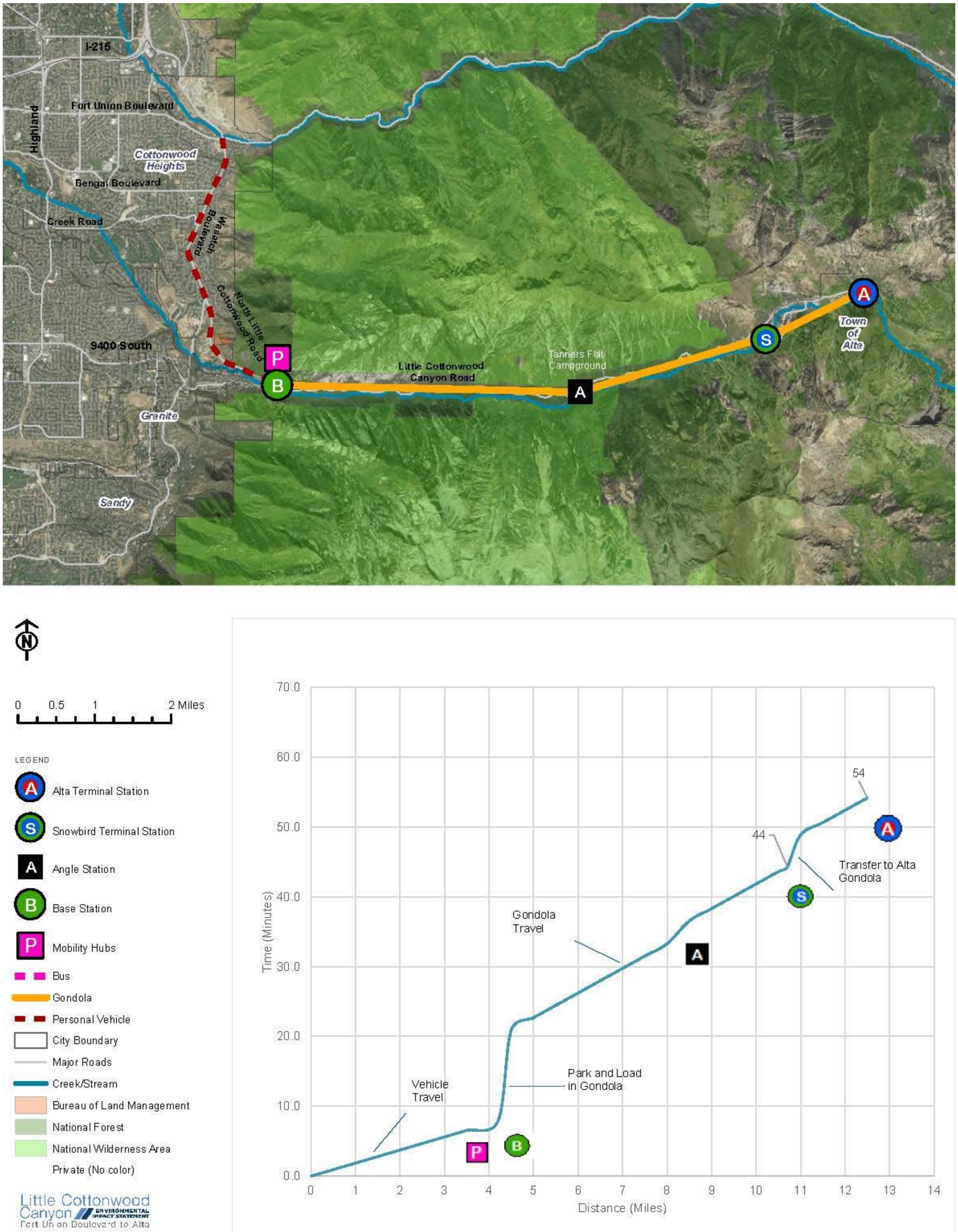
The estimated vehicle travel time in 2050 along Wasatch Boulevard is about 8 minutes from Fort Union Boulevard to the mouth of Little Cottonwood Canyon. This travel time assumes that Wasatch Boulevard has been expanded to accommodate the projected travel demand in 2050. With about 500 vehicles trying to park at the expanded park-and-ride lot or new parking structure at the intersection of S.R. 209 and S.R. 210 during the peak period, there could likely be some congestion at the intersection. However, this analysis assumes that the intersection of S.R. 210 and S.R. 209 can be improved, that vehicles can access the area efficiently, and that vehicles would not back up onto S.R. 210 or neighborhood streets.

UDOT added 12 minutes to the initial 8-minute segment time to account for the time to drive into the parking structure, park a vehicle, unload gear, walk to the gondola loading area, pay for a fare, board the gondola cabin, and depart the base station.[10] Adding the 24-minute gondola ride, the resulting total travel time is about **44 minutes to Snowbird**. Assuming a 3.5-minute mode shift to a separate gondola system and a 1½-mile, 5½-minute ride on the gondola to Alta, the total travel time for Scenario 1 would be about **54 minutes to Alta**.

Figure 2 shows a map with the locations of the major components that make up this scenario. Note that the starting point for travel under this scenario is the intersection of Fort Union Boulevard and Wasatch Boulevard. Scenario 1 includes a personal vehicle trip (a dashed red line in the figure) from this starting point to the base station at the mouth of the canyon. Then the remaining segments are a gondola trip (solid orange line) from the base station through an angle station and on to the resorts. Figure 2 also presents a graph, which is a cumulative travel time chart for each segment. The horizontal axis on the graph represents the distance from the starting point to a gondola system component (base station, angle station, or terminal station), and the vertical axis is the travel time from the starting point to that component.

[10] These additional 12 minutes consist of the following times and activities: 0.5 minute to wait in the line of vehicles at the parking garage, 1 minute to find a parking spot, 4 minutes to unload gear, 3.5 minutes to walk to the gondola loading area (assumed to be a 900-foot distance at a 3-mph pace), 1 minute to pay for a fare, and 2 minutes waiting in line to board the gondola cabin.

Figure 2. Scenario 1 Map and Travel Time Graph



5.1.3 Cost Estimate

Capital Cost

The capital cost for Scenario 1 was established by estimating the costs for the different gondola components needed to load passengers and reach the terminal stations. These are rough order-of-magnitude costs and are for comparison purposes only. The scenario components include the following:

- **Lift System.** The cost estimate for gondola cabling, cabins, and towers uses an assumed cost per mile of about $18 million.[11]
- **Terminal Stations.** The cost estimate for the base and destination stations uses a cost per station for power equipment, emergency backup power, gondola controls, sensors, loading platforms, and mechanical equipment. UDOT estimated these costs to be about $11 million per terminal station.
- **Resort Interface for Terminal Stations.** Required terminal station infrastructure, or "resort interface," costs are included to address utilities, site civil works, and building enclosure needs. UDOT estimated these costs to be about $6 million per terminal station.
- **Angle Station.** No loading or unloading of passengers occurs at angle stations (unless emergency evacuation is needed). However, the angle stations require power and equipment to decelerate and maneuver the detached cabins slowly through the angle station. The approximate cost for angle stations and their required infrastructure was assumed to be about 60% of the terminal station cost (to account for utilities and civil work), or about $10.2 million total.
- **Parking.** The cost estimate for the parking structure uses a per-space average of about $64.77 per square foot.[12] Assuming a 2,500-car parking structure, the total cost for this structure would be about $52 million.

It is important to note that right-of-way costs and costs to relocate existing infrastructure are *not* included in these rough order-of-magnitude costs.

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[11] Gondola lift system costs include costs for mechanical equipment, cabins, and towers. Component costs were estimated from costs presented in the *Mountain Transportation Study* (Fehr and Peers 2012), which were based on the constructed cost of the Whistler-Blackcomb Peak-to-Peak 3S Gondola in 2012. Total costs were broken down to the various components using percentages of the total and were inflated by 1.31 representing the difference between the ENR Construction Index 2012 and May 2019 dollars. UDOT also reviewed the *Aerial Cable Transit Feasibility Study* (Jacobs Engineering Group 2016) commissioned by the Miami-Dade Metropolitan Planning Organization in Florida, the *Sorrento Valley Skyway Feasibility Study* (WSP/Parsons Brinkerhoff 2017), and the *San Diego Bay to Balboa Park Skyway Feasibility Study* (Parsons Brinkerhoff and others 2015), the latter two of which were commissioned by the San Diego Association of Governments, to determine approximate gondola lift system and station costs, including required site infrastructure. In addition, Leitner-Poma (2018) provided a budgetary cost for a gondola lift system from the mouth of Little Cottonwood Canyon 6.5 miles to Snowbird. UDOT used these references to determine the terminal costs, terminal infrastructure costs, and per-mile gondola system cost (mechanical systems, towers, and cabins), as well as annual operation and maintenance costs.

[12] The per-parking-spot, planning-level capital cost estimate for a parking structure was provided to UDOT by its parking consultant, DESMAN Corporation.

Adding these component costs for Scenario 1 produces a total estimated cost of about $262,600,000 to $288,860,000, with the high estimate including an additional 10% contingency. Table 2 provides a breakdown of the capital cost. Also see Appendix B, Aerial Transit Cost Estimates.

Table 2. Scenario 1 Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	8.3 miles	18,000,000	149,400,000
Terminal stations	3 stations	11,000,000	33,000,000
Resort interface for terminal stations	3 stations	6,000,000	18,000,000
Angle station	1 station	10,200,000	10,200,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Total Low Estimate			**262,600,000**
Contingency (10% of low estimate)	—	—	26,260,000
Total High Estimate			**288,860,000**

Annual O&M Cost

Annual operation and maintenance (O&M) costs include labor, annual contribution of funds to a capital replacement reserve account to pay for periodic major capital replacements and refurbishments, and miscellaneous costs for maintaining the gondola system. These miscellaneous costs include spare system parts, tools, and consumables (lubricants); staff uniforms and vehicles; and power to run the motors and monitoring equipment.

The annual O&M costs are discussed below. For more information, see Appendix B, Aerial Transit Cost Estimates.

- **Operating Assumptions.** UDOT assumes that the gondola would operate for about 140 days in the winter months between 7:00 AM and 7:00 PM. A gondola system would be a large investment, and UDOT or private operator would want to maximize its use and collect as much in fares as possible to pay for the gondola's capital investment and operation. (A market assessment and determination of the potential annual ridership was outside the scope of the initial ATS evaluation presented in this report.) With the above inputs, the gondola would operate for 1,680 hours per year under every scenario.
- **Labor Costs.** As described in Section 4.2.3, Staffing, operating the gondola requires several different categories of labor. Staffing estimates for the conceptual Little Cottonwood Canyon gondola were based on staffing numbers provided in aerial transit feasibility reports commissioned by the Miami-Dade Metropolitan Planning Organization (Jacobs Engineering Group 2016) and by the San Diego Association of Governments (SANDAG) (Parsons Brinkerhoff and others 2015). An experienced gondola manufacturer, Doppelmayr USA, Inc., participated in the latter study. According to these studies, the per-shift staffing needs for the Scenario 1 gondola are 18 people: 2 managers, 1 electrician, 1 mechanic, 3 operators, 10 parking and platform attendants, and 1 administrative support person. UDOT scaled these staffing numbers for the longer gondola alignments

(Scenarios 3 and 4). The total labor needs and costs were determined by estimating the total labor needs for the annual operating hours (1,680 hours) and applying a burdened hourly rate for each labor category. The total annual labor cost is estimated to be about $1,476,000 for Scenario 1.

- **Major Equipment Replacement Reserves.** Moving gondola system components (cables, motors, and grips) wear and therefore have a finite life. They would need to be replaced near the end of their useful life (about 15 years). In addition, gondola cabins need to be refurbished about every 20 years. UDOT used the SANDAG report from 2015 (Parsons Brinkerhoff and others 2015) as the basis for determining replacement costs and useful life. UDOT calculated a per-mile cost from that study (which evaluated a 2.5-mile 1S gondola) and applied a per-mile replacement cost to the length of the Scenario 1 alignment (8.3 miles) to determine the replacement cost for Scenario 1. Based on this calculation, about $453,000 would need to be set aside annually to establish a fund to replace the system components and refurbish cabins for Scenario 1.
- **Miscellaneous Costs.** These costs include spare parts, lubricants, insurance, annual cable and gondola system inspections, staff vehicles, tools, and other “soft” operating costs. These miscellaneous O&M costs are estimated to total about $990,000 annually for Scenario 1.
- **Energy Costs.** Electricity is needed to power the haul cable motors, the mechanical components in each station, and the monitoring and communication equipment as well as lights and fire and life safety systems at the stations. A conceptual design produced by Leitner-Poma (2018) determined that two 550-horsepower motors would be needed to operate a lift system between the base station at the mouth of Little Cottonwood Canyon and Snowbird. UDOT assumed that a third motor would be needed to operate the segment between Snowbird and Alta. At the assumed operating hours and at a cost of $0.0819 per-kilowatt-hour, the total energy cost is estimated to be about $227,000 annually for Scenario 1.

Table 3 provides a breakdown of annual O&M costs for Scenario 1 by category and a total rough order-of-magnitude annual cost. The total annual O&M cost for Scenario 1 is estimated at about $3,144,000 to $3,458,400.

Table 3. Scenario 1 Annual O&M Cost Estimate

O&M Category	Annual Cost ($)
Labor costs	1,476,000
Major equipment replacement reserves	453,000
Miscellaneous costs	990,000
Energy costs	227,000
Subtotal[a]	**3,144,000**
Contingency (10%)	314,400
Total	**3,458,400**

[a] Also see Appendix B, Aerial Transit Cost Estimates. Numbers might not match exactly due to rounding.

5.2 Scenario 2 – Expanded Parking and Base Station 1 to 1½ Miles from the Mouth of the Canyon

5.2.1 Parking Location and Gondola Alignment

The steep slopes around the existing park-and-ride lot at the mouth of Little Cottonwood Canyon might limit the size of a new parking structure. In addition, S.R. 210 and S.R. 209 merge at this location, which causes traffic to back up. Therefore, a large parking structure at the location identified in Scenario 1 might not provide any congestion-reduction benefits. Because of these constraints, the *Mountain Transportation Study* (Fehr and Peers 2012) explored a conceptual parking structure and base station located about 1 to 1½ miles northwest of the existing Little Cottonwood Canyon park-and-ride lot along the west side of S.R. 210. UDOT also evaluated this scenario for the EIS.

Given the location of the parking structure and base station with Scenario 2, the gondola alignment would extend in a 1 to 1½-mile straight segment that crosses S.R. 210 twice and runs to an angle station southwest of the Wasatch Resorts and south of Little Cottonwood Creek. The second straight segment would run south of the Wasatch Resorts, traveling about 4 miles to a second angle station near Tanners Flat. This alignment also places the second angle station south of the creek near Tanners Flat. (This angle station could be moved north of the creek to avoid a long access road and bridge, but alternate locations were not evaluated for this report.) From Tanners Flat, a third straight segment would run about 2 miles to Snowbird. The fourth straight segment would connect Snowbird to Alta, a distance of about 1½ miles.

The base station for Scenario 2 would be in between two residential areas. The first straight segment would run along the east side of S.R. 210 along the foothills. The second straight segment would run past the Wasatch Resorts. Privacy issues would be a concern with this segment. At least one (and maybe two) angle stations would be located south of the creek and would require a maintenance road, a bridge over the creek, and base and emergency power.

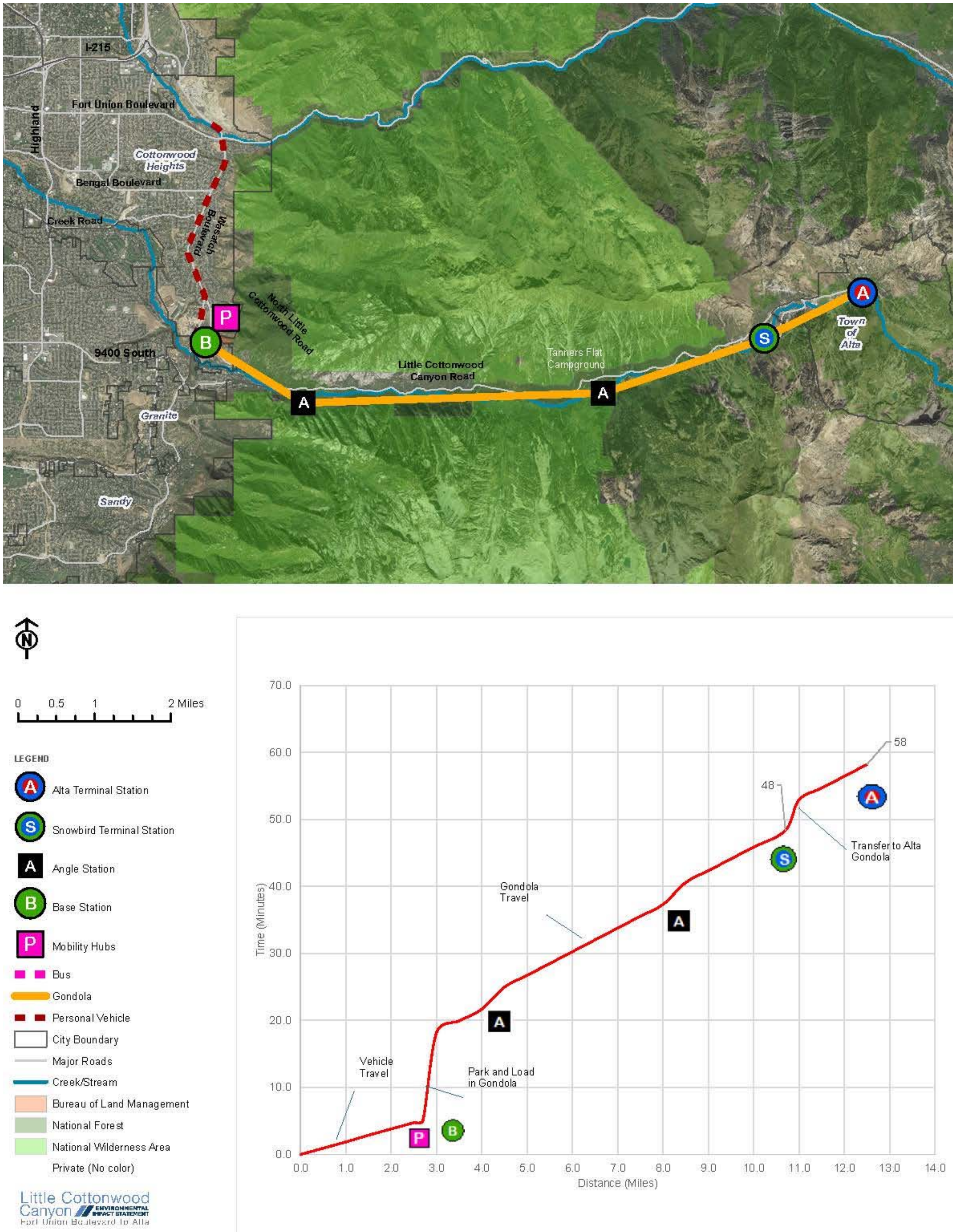
5.2.2 Travel Time

> **What would be the total travel time to Snowbird and Alta with Scenario 2?**
>
> With Scenario 2, the total travel time would be about 48 minutes to Snowbird and about 58 minutes to Alta.

The additional 1½-mile gondola segment from Snowbird to Alta would add about 7 minutes to the gondola travel time (6 minutes plus 1 minute to go through the additional angle station). The resulting gondola travel time from the parking structure and base station would be about 31 minutes to Snowbird and about 40 minutes to Alta.

In terms of the overall travel time from the intersection of Fort Union Boulevard and Wasatch Boulevard, the vehicle travel time would be slightly reduced (from about 8 to 5 minutes) compared to Scenario 1. Adding the time for a rider to park their car, walk to the gondola platform, and board the gondola cabin, the total travel time would be about **48 minutes to Snowbird** and, with the transfer to a separate gondola system for the last segment, **about 58 minutes to Alta** (Figure 3).

Figure 3. Scenario 2 Map and Travel Time Graph



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5.2.3 Cost Estimate

Capital Cost

The total estimated capital cost for Scenario 2 is about $299,800,000 to $329,780,000. A cost breakdown is provided in Table 4. The higher cost ($40,900,000) compared to Scenario 1 can be attributed to the 1 to 1½-mile longer total length and the need for an additional angle station.

Table 4. Scenario 2 Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	9.8 miles	18,000,000	176,400,000
Terminal stations	3 stations	11,000,000	33,000,000
Resort interface for terminal stations	3 stations	6,000,000	18,000,000
Angle stations	2 stations	10,200,000	20,400,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Total Low Estimate			**299,800,000**
Contingency (10% of low estimate)	—	—	29,980,000
Total High Estimate			**329,780,000**

Annual O&M Cost

The O&M cost for Scenario 2 would be essentially the same as for Scenario 1. A similar number of staff would be needed. The miscellaneous costs and power costs would be about the same. More gondola cabins would be needed for the extra length of this alignment, and, compared to Scenario 1, more cabins would eventually need to be refurbished. However, the difference in the major equipment replacement reserves would be negligible. Therefore, the total O&M cost for Scenario 2 is also estimated at about $3.1 million to $3.5 million.

5.3 Scenario 3 – Gravel Pit Mobility Hub

5.3.1 Parking Location and Gondola Alignment

This scenario would place a parking structure at a site of an aggregate (gravel) mining operation that is just east of Wasatch Boulevard and north of Fort Union Boulevard near the mouth of Big Cottonwood Canyon. The parking structure would allow this location to function as a “mobility hub” from which users could take various transit options.

A main benefit of this location is that it would take cars away from the mouth of Little Cottonwood Canyon, which is where S.R. 210 and S.R. 209 merge and where traffic congestion is heavy during the current winter AM peak period. This location is near Interstate 215 (I-215) and would not add traffic to a residential area. Another benefit of this location as a mobility hub is that it could serve transit users traveling to either Big Cottonwood Canyon or Little Cottonwood Canyon, as well as serve weekday commuters in the future as UTA and UDOT explore long-term transit options for this part of the Salt Lake Valley. Parking could also be developed in conjunction with a future commercial or mixed-use development in the area. UDOT has coordinated with the City of Cottonwood Heights regarding this possibility.

For canyon users originating from the north part of the Salt Lake Valley (north of Fort Union Boulevard), this mobility hub would be on their route. However, canyon users who originate from south of 9400 South (S.R. 209) would need to bypass Little Cottonwood Canyon and drive about 3 more miles north to this mobility hub before boarding the gondola.

Two options were explored for accessing the gondola under Scenario 3.

- With **Option A (Complete Gondola Alignment)**, users would board the gondola at a base station at the mobility hub at the gravel pit and then transfer to a second gondola system at a second base station at the mouth of Little Cottonwood Canyon. This would be a complete gondola alignment (no bus service) that begins in the urban environment.
- With **Option B (Express Bus to Gondola Alignment)**, users would take an express bus from the mobility hub at the gravel pit to a base station at the mouth of Little Cottonwood Canyon.

These Scenario 3 options are described in greater detail below.

Scenario 3A – Complete Gondola Alignment

With Scenario 3A (Figure 4 on page 25), the gondola alignment that would connect the mobility hub at the gravel pit to Little Cottonwood Canyon would be very challenging. There are existing homes on both sides of Wasatch Boulevard. The *Mountain Transportation Study* (Fehr and Peers 2012) explored two alignments that would connect a base station at the mobility hub to a base station at the mouth of Little Cottonwood Canyon.

The alignment that appears to have the least impacts to the current residential areas would run south from the gravel pit, fly over homes along the east side of Wasatch Boulevard for about 1 mile (likely requiring the acquisition of at least 10 to 15 residences), and include an angle station in Ferguson Canyon. From there, the gondola alignment would skirt the western edge of USDA Forest Service land for about 3 miles to the mouth of the canyon. This segment of the gondola alignment would run past existing homes east of Wasatch Boulevard. Two angle stations would likely be needed in the urban segment. From the mouth of the canyon, the gondola alignment would be similar to that for Scenario 1.

Scenario 3B – Express Bus to Gondola Alignment

With Scenario 3B (Figure 5 on page 27), gondola users would park their vehicle at the gravel pit mobility hub and then travel via express bus from the mobility hub to a base station at the mouth of Little Cottonwood Canyon. This option would avoid siting a large parking area at the mouth of Little Cottonwood Canyon, would keep traffic away from residential areas, and would avoid a difficult gondola alignment that would run through or adjacent to residential areas. However, gondola users would need to change travel modes twice: from vehicle to bus and then from bus to gondola for the trip up the canyon.

In general, a “one-seat ride” (either vehicle or transit) is most preferable to users. One mode shift, or a “two-seat ride,” is less desirable but is still acceptable to many users as evidenced by the use of the existing park-and-ride lots and ski bus service. Shifting travel modes twice, or a “three-seat ride,” would likely be unpopular but could be acceptable to some users if the travel time were shorter than with other available options. If resort parking becomes more limited in the future, or if future policy decisions limit automobile use in the canyon and buses are given priority in traffic, a vehicle-to-bus-to-gondola trip could be a reasonable scenario. Considering the difficulty in establishing an acceptable gondola alignment between the canyons, UDOT evaluated the travel times and the cost of Scenario 3B as it considers and compares all feasible and reasonable concepts to evaluate in detail in the EIS.

5.3.2 Travel Time

Scenario 3A – Complete Gondola Alignment

Scenario 3A involves a complete gondola trip from the starting point (the intersection of Wasatch Boulevard and Fort Union Boulevard) to the ski resorts, a total distance of about 12.5 miles. The travel time considerations for this gondola scenario (parking, walking, and gondola loading times) are the same as those described in Section 5.1.2, Travel Time.

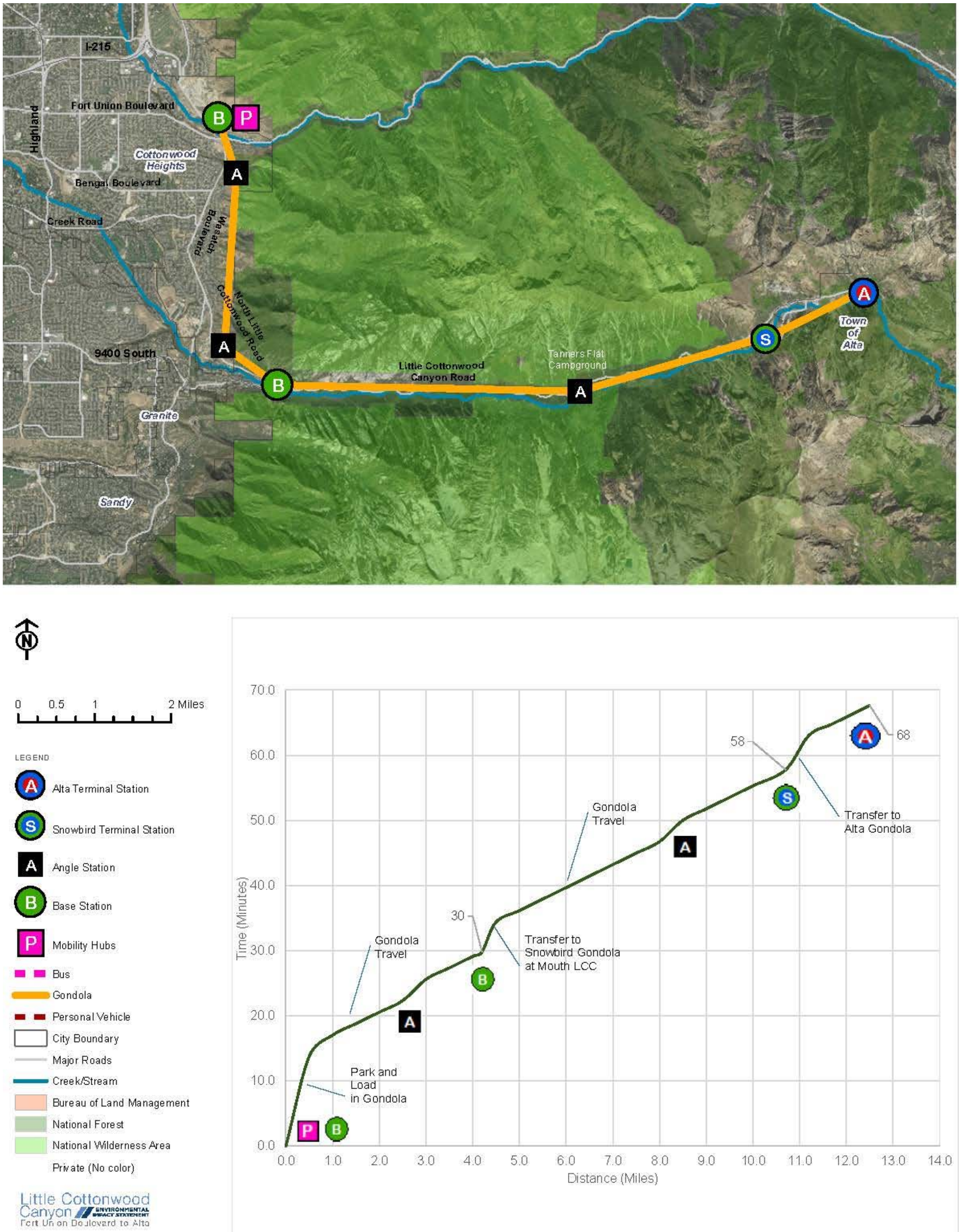
What would be the total travel time to Snowbird and Alta with Scenario 3A?

With Scenario 3A, the total travel time would be about 58 minutes to Snowbird and about 68 minutes to Alta.

Previous studies theorized that a different type of gondola could be used to connect Big and Little Cottonwood Canyons, and UDOT believes it is unlikely that one operationally connected cabling system could be used for this length of gondola system with its several angle stations. Therefore, to be conservative, UDOT has assumed that users would transfer from one gondola system to another at the mouth of Little Cottonwood Canyon.

The travel time for accessing and traveling in a gondola from the start point to the mouth of Little Cottonwood Canyon would be about 30 minutes. Adding the gondola transfer time (3.5 minutes) and the gondola travel time from the mouth of the canyon to the resorts results in a total travel time of about **58 minutes to Snowbird** and about **68 minutes to Alta** (Figure 4). The travel time for this scenario is about 14 minutes longer than with Scenario 1 (parking and base station at the mouth of Little Cottonwood Canyon).

Figure 4. Scenario 3A Map and Travel Time Graph



Scenario 3B – Express Bus to Gondola Alignment

With Scenario 3B, gondola riders would park their vehicles at the gravel pit mobility hub, take an express bus for 4.2 miles to a base station at the mouth of the canyon, and then transfer to a gondola.

Whereas the gondola system would offer nearly constant service (a gondola cabin would arrive about every 30 seconds), the express buses would arrive at a longer intervals, and the wait time for a bus could be longer than for a gondola. UDOT assumed that Scenario 3B would use articulated buses with a capacity of about 60 people per bus. These buses could be electric and would have three loading doors.

UDOT assumed a bus wait time of 2 minutes. Therefore, the assumed parking, walking, and waiting time at the starting point is about 12 minutes.

With Scenario 3B, the segment of the trip between the starting point and the mouth of the canyon would be about 25 minutes, about 5 minutes faster than with the complete gondola alignment (Scenario 3A). The assumed speed of the bus (20 mph[13]) is faster than the assumed speed of the gondola (17 mph[14]). Adding the 3.5-minute bus-to-gondola transfer time at the base station at the mouth of the canyon and the gondola travel time, the total travel time with this option would be about **53 minutes to Snowbird** and about **62 minutes to Alta** (Figure 5).

What would be the total travel time to Snowbird and Alta with Scenario 3B?

With Scenario 3B, the total travel time would be about 53 minutes to Snowbird and about 62 minutes to Alta.

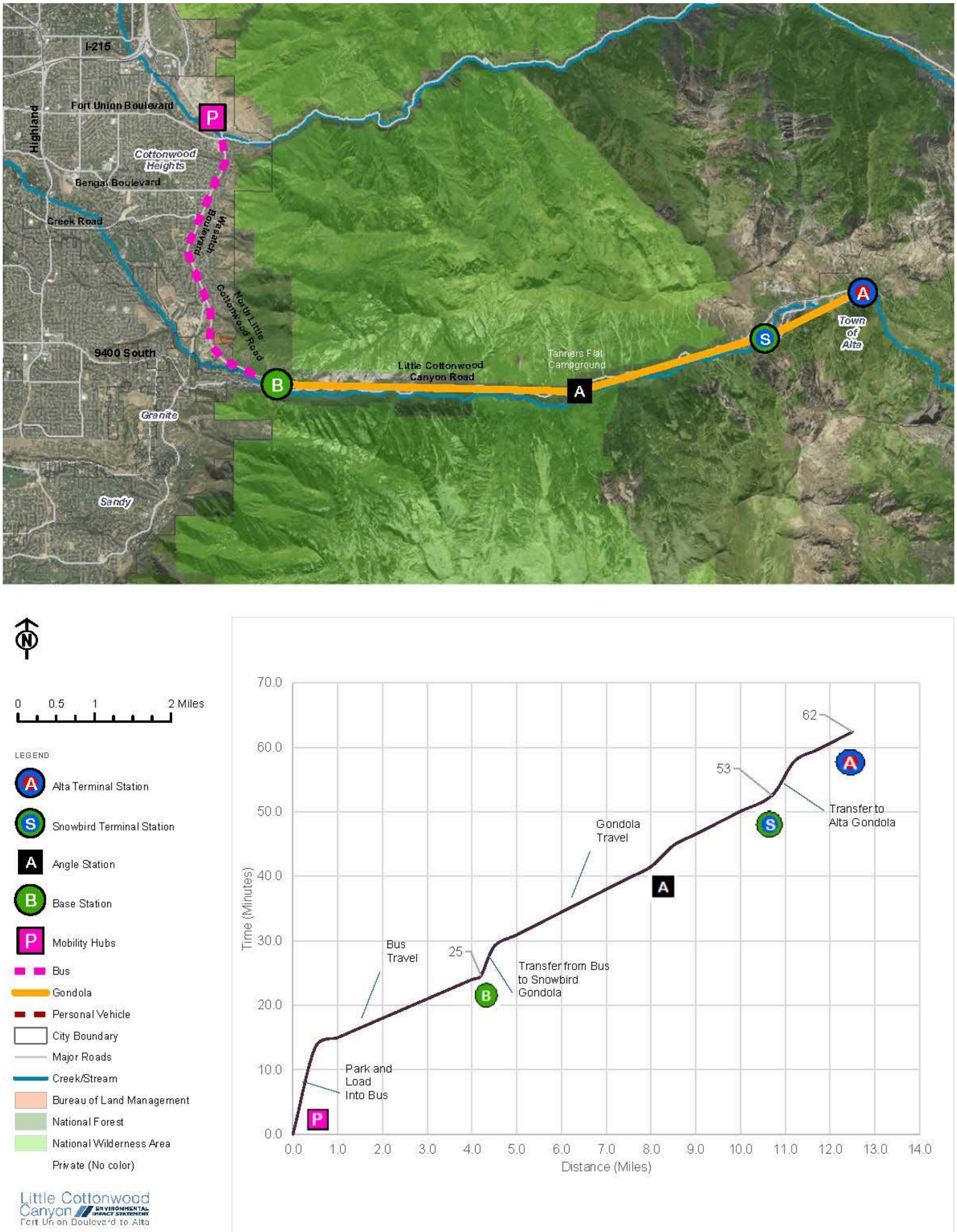
What is an articulated bus?

An articulated bus is an extended bus in which two or more sections are linked with pivoting joints to accommodate more passengers while still allowing the bus to maneuver.

[13] Operating bus speed is assumed to be equivalent to bus rapid transit operating in an urban area (20 mph).

[14] Gondola operating speed is taken from the *Mountain Transportation Study* (Fehr and Peers 2012).

Figure 5. Scenario 3B Map and Travel Time Graph



5.3.3 Cost Estimate

Scenario 3A – Complete Gondola Alignment

Capital Cost

Scenario 3A includes the same general components as Scenarios 1 and 2. However, this gondola alignment would need two more angle stations than Scenario 1 and one more angle station than Scenario 2. The length of the gondola alignment would be about 12.5 miles, 4.2 miles longer than with Scenario 1. UDOT also assumes that a gondola system transfer at the mouth of the canyon would be needed, requiring another base station (four terminal stations total) for this scenario. Table 5 provides the breakdown of capital costs. Note that these costs do not include right-of-way or property acquisition costs.

Table 5. Scenario 3A Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	12.5 miles	18,000,000	225,000,000
Terminal stations	4 stations	11,000,000	44,000,000
Resort interface for terminal stations	4 stations	6,000,000	24,000,000
Angle stations	3 stations	10,200,000	30,600,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Total Low Estimate			**375,600,000**
Contingency (10% of low estimate)	—	—	37,560,000
Total High Estimate			**413,160,000**

Annual O&M Cost

The additional gondola system segment (base station to the mouth of the canyon) would lead to additional O&M costs. These additional considerations are as follows.

- **Labor Costs.** UDOT scaled up Scenario 1's per-shift staffing needs to arrive at the staffing needs for the Scenario 3A gondola system. The staffing needs for Scenario 3A would be about 22 positions per shift: 1 administrative professional, 2 managers, 1 electrician, 2 mechanics, 4 operators, and 12 parking and platform attendants. The total labor cost for Scenario 3A would be about $1,816,000, which is about $340,000 more than for Scenario 1 or 2.
- **Major Equipment Replacement Reserves.** UDOT used a per-mile replacement cost that was calculated for Scenario 1 and applied it to Scenario 3A (with an alignment of 12.5 miles). Two additional motors (five total) would be needed for this scenario. About $673,000 would need to be set aside annually to establish a fund to replace the major system components and refurbish cabins for Scenario 3A. This is about 49% more than for Scenario 1 or 2.
- **Miscellaneous Costs.** Similar to the method used to calculate equipment replacement and refurbishment costs, miscellaneous annual costs were calculated using a per-mile unit cost. UDOT estimated the annual miscellaneous costs for Scenario 3A by adding 49% to the miscellaneous

costs for Scenarios 1 and 2 (which have about the same miscellaneous costs). A total of about $1,469,000 would need to be budgeted for this cost item for Scenario 3A.

- **Energy Costs.** Assuming that Scenario 3A would have five motors and the same operating hours as Scenarios 1 and 2, the energy costs of Scenario 3A would be about $378,000 per year.

Table 6 provides a breakdown of annual O&M costs for Scenario 3A by category and a total rough order-of-magnitude annual cost. This 12.5-mile gondola would cost about $4,337,000 to $4,770,700 annually to operate and maintain.

Table 6. Scenario 3A Annual O&M Cost Estimate

O&M Category	Annual Cost ($)
Labor costs	1,816,000
Major equipment replacement reserves	673,000
Miscellaneous costs	1,469,000
Energy costs	378,000
Subtotal[a]	**4,337,000**
Contingency (10%)	433,700
Total[a]	**4,770,700**

[a] Also see Appendix B, Aerial Transit Cost Estimates. Numbers might not match exactly due to rounding

Scenario 3B – Express Bus to Gondola Alignment

Capital Cost

The gondola system for Scenario 3B is the same as for Scenario 1. This option replaces Scenario 3A’s gondola alignment through the initial urban segments with express bus service and adds the capital cost of these buses.

UDOT assumed that articulated buses could be used to transport people from the parking area at the gravel pit to the base station at the mouth of Little Cottonwood Canyon. These articulated buses have a higher capacity per bus (60 people maximum) compared to regular buses and ski buses (which have a maximum capacity of about 42 people). Assuming that a bus can make two round trips per hour, each articulated bus could transport 120 people per hour. If 1,000 people per hour need to be moved, about 8 buses would be required. Adding a 20% “spare ratio” to account for breakdowns and maintenance needs, this option would require 10 buses total. At about $1,100,000 per articulated bus, the total capital cost for buses would be about $11,000,000.

The cost estimate in Table 7 also includes a budgetary number of $10 million for improving shoulders to allow the buses to use them during times of heavy traffic, for adding “queue jump” lanes and traffic signal priority systems that would allow buses to get to the front of the line at intersections, and for building a maintenance and bus storage facility near the parking area.

Table 7 summarizes the breakdown of capital costs for Scenario 3B. The capital cost of this scenario is about $94 million less than the cost of Scenario 3A.

Table 7. Scenario 3B Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	8.3 miles	18,000,000	149,400,000
Terminal stations	3 stations	11,000,000	33,000,000
Resort interface for terminal stations	3 stations	6,000,000	18,000,000
Angle station	1 station	10,200,000	10,200,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Enhanced bus service	1 lump sum	21,000,000	21,000,000
Total Low Estimate			**283,600,000**
Contingency (10% of low estimate)	—	—	28,360,000
Total High Estimate			**311,960,000**

Annual O&M Cost

This gondola alignment and parking scenario would include O&M costs for both gondola and bus. The gondola O&M cost would be the same as that for Scenario 1, which would be about $3.5 million annually.

As described in the previous section for capital cost, about 10 buses would be needed to accommodate the same hourly capacity as was assumed for the gondola (1,000 people per hour). Assuming that each bus can make two round trips each hour between the gravel pit mobility hub and the gondola base station at the mouth of Little Cottonwood Canyon, which are 4.2 miles apart, about 840 bus-fleet miles per day would be driven. If the buses operate at the same times as the gondola (12 hours per day for 140 days), about 11,760 miles would be driven per year. Using an operating expense per vehicle revenue mile of $7.88 per mile, the total annual O&M cost for buses would be about $927,000 ($1,020,000 including a 10% contingency) (UTA 2019).

Table 8 presents the estimated total annual O&M cost for Scenario 3B. This 8.3-mile gondola alignment with three terminal stations and with express bus service transporting users to the base terminal at the mouth of the canyon would cost about $4.5 million annually to maintain and operate.

Table 8. Scenario 3B Annual O&M Cost Estimate

O&M Category	Annual Cost ($)
Labor costs	1,476,000
Major equipment replacement reserves	453,000
Miscellaneous costs	990,000
Energy costs	227,000
Gondola Subtotal	**3,146,000**
Bus O&M	927,000
Subtotal	**4,073,000**
Contingency (10%)	470,000
Total[a]	**4,543,000**

[a] Also see Appendix B, Aerial Transit Cost Estimates. Numbers might not match exactly due to rounding.

Bus service can be more easily optimized than can gondola service to accommodate the actual hourly demand. The number of buses arriving per hour can be adjusted, whereas the number of gondola cabins arriving per hour is fixed. UDOT created a modified bus schedule for Scenario 3B (Table 9) to account for the difference in expected transit demands between winter weekend (including Fridays) peak and off-peak hours and winter weekday demands.

With the modified schedule, maximum bus operations (3 to 4-minute frequency or headways) would occur for about 6 hours per day for 60 weekend days (including Fridays) per year. The bus capacity during peak hours would be about 1,000 people per hour. The bus frequency would be reduced to a 15-minute headway for the remaining 6 hours of weekend operating times. During the winter weekdays, UDOT assumes that there would be 30-minute bus headways between the gravel pit mobility hub and the base gondola station at the mouth of Little Cottonwood Canyon.

Table 9. Modified Bus Schedule for Scenario 3B

Schedule	Hours of Operation	Frequency (minutes)	Trips per Hour	Trips per Day	Days of Operation	Total Trips
Winter weekends, peak hours Friday–Sunday 7–10 AM and 3–6 PM	6	3	20	120	60	7,200
Winter weekends, off-peak hours Friday–Sunday 10 AM–3 PM and 6–7 PM	6	15	4	24	60	1,440
Winter weekdays, all hours Monday–Thursday 7 AM–7 PM	12	30	2	24	80	1,920
Total Trips						**10,560**

Table 9 above shows the estimated total number of bus trips per year (10,560) with Scenario 3B. The one-way distance between the gravel pit mobility hub and the base gondola station is about 4.2 miles (8.4 miles round trip). Given an estimated 10,560 annual bus trips, about 88,704 fleet-miles per year would be traveled. Using an operating expense per vehicle revenue mile of $7.88 per mile, the total annual O&M cost for buses with this scenario would be about $699,000. As shown in Table 10, the O&M cost for Scenario 3B with a modified bus schedule would be about $3.8 million to $4.2 million annually. Optimizing the hourly bus service to the gondola would save about $0.3 million annually.

Table 10. Scenario 3B (with Modified Bus Schedule) Annual O&M Cost Estimate

O&M Category	Annual Cost ($)
Labor costs	1,476,000
Major equipment replacement reserves	453,000
Miscellaneous costs	990,000
Energy costs	227,000
Gondola Subtotal	**3,146,000**
Bus O&M	699,000
Subtotal	**3,845,000**
Contingency (10%)	384,000
Total[a]	**4,229,500**

[a] Also see Appendix B, Aerial Transit Cost Estimates. Numbers might not match exactly due to rounding.

5.4 Scenario 4 – 9400 South and Highland Drive Mobility Hub

5.4.1 Parking Location and Gondola Alignment

Another scenario for implementing a mobility hub would be expanding parking near the existing park-and-ride lot at 9400 South (S.R. 209) and Highland Drive. Although this area is outside the EIS transportation needs assessment study area, UDOT wanted to evaluate the potential merits of gondola use in Little Cottonwood Canyon, and this is one feasible possibility for a mobility hub. A benefit of this site for a mobility hub is that parking itself would be near existing commercial developments and away from both residential areas and the junction of S.R. 210 and S.R. 209 at the mouth of the canyon.

For canyon users traveling from the south, this mobility hub, which would be about 3.5 miles from Interstate 15, would be on their route. However, canyon users traveling from the north would need to drive about 6 miles farther south from I-215 to reach this parking location.

As with Scenario 3, two options were explored for accessing the gondola under Scenario 4.

- With **Option A (Complete Gondola Alignment)**, users would board the gondola at a base station at the mobility hub at 9400 South and Highland Drive and then transfer to a second gondola system at a second base station at the mouth of Little Cottonwood Canyon. This would be a complete gondola alignment (no bus service) that begins in the urban environment.
- With **Option B (Express Bus to Gondola Alignment)**, users would take an express bus from the mobility hub at 9400 South and Highland Drive to a base station at the mouth of Little Cottonwood Canyon.

These Scenario 4 options are described in greater detail below.

Scenario 4A – Complete Gondola Alignment

With Scenario 4A (Figure 6 on page 35), a gondola alignment from the 9400 South mobility hub would run 3½ miles to the mouth of Little Cottonwood Canyon. This would be a very challenging alignment because of the narrow roadway and adjacent residential areas. The area along 9400 South from just east of Highland Drive to the mouth of the canyon has dense residential development. 9400 South is currently four lanes (two lanes in each direction) near the potential mobility hub but transitions to two lanes about ¾ mile east of the mobility hub, at about 2350 East, and is only two lanes from there to the intersection of 9400 South and S.R. 210 at the mouth of Little Cottonwood Canyon. A gondola alignment would need to follow 9400 South for the entire segment to avoid major residential impacts. Only at 9400 South and Wasatch Boulevard could the gondola alignment divert from the road to run south of residential neighborhoods to the mouth of the canyon.

At least six angle stations would be needed to reach the base station at the mouth of Little Cottonwood Canyon. Having six angle stations would slow the average speed of the gondola significantly. UDOT assumes that users would transfer to a second gondola system at the mouth of the canyon because it is unlikely that one continuous-haul cabling system could connect the gondola system for the entire 11.5 miles.

Scenario 4B – Express Bus to Gondola Alignment

With Scenario 4B (Figure 7 on page 37), express bus service using articulated buses would connect gondola riders from the 9400 South mobility hub to a base station at the mouth of Little Cottonwood Canyon (similar to Scenario 3B). Gondola riders would need to change travel modes twice: from vehicle to bus and then from bus to gondola for the trip up the canyon.

5.4.2 Travel Time

Scenario 4A – Complete Gondola Alignment

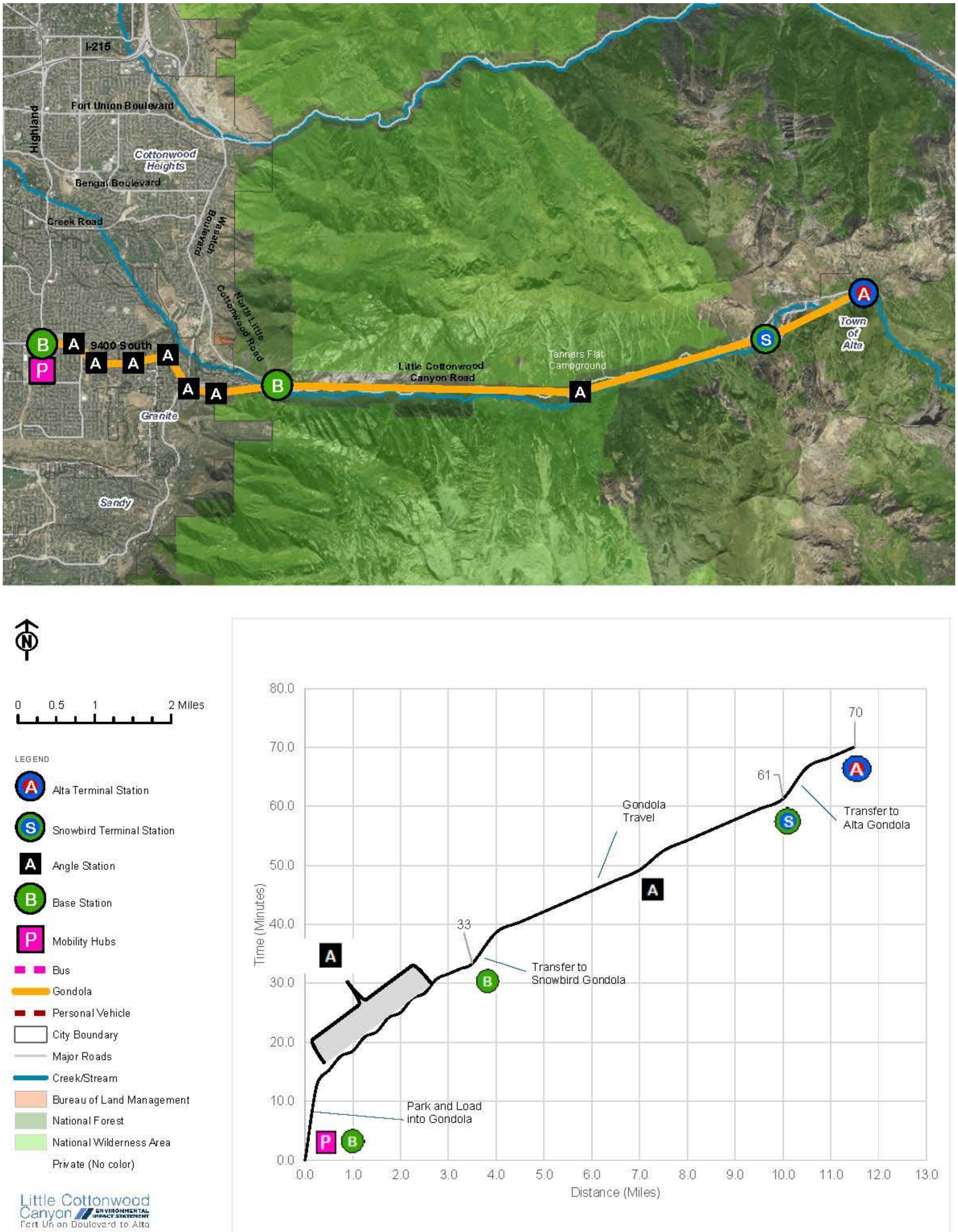
With Scenario 4A, it would take a gondola rider about 33 minutes to get from 9400 South and Highland Drive to the mouth of the canyon considering parking, walking, gondola loading times, and time to pass through the angle stations. The total travel time would be about **61 minutes to Snowbird** and about **70 minutes to Alta** (Figure 6).

Note that this travel time does not include the travel time from the starting point, Wasatch Boulevard and Fort Union Boulevard. Therefore, a comparison to Scenarios 1, 2, and 3 is not appropriate.

What would be the total travel time to Snowbird and Alta with Scenario 4A?

With Scenario 4A, the total travel time would be about 61 minutes to Snowbird and about 70 minutes to Alta.

Figure 6. Scenario 4A Map and Travel Time Graph



Scenario 4B – Express Bus to Gondola Alignment

With Scenario 4B, it would take a bus rider about 23 minutes to get from 9400 South and Highland Drive to the mouth of the canyon considering parking, walking, bus loading times, and bus travel times. Note that this calculation used an average assumed speed of 20 mph. 9400 South is only two lanes for much of segment between Highland Drive and the intersection with S.R. 210, and there are many homes on both sides of the road. Shoulder and intersection improvements alone might not effective for maintaining the assumed speed of the articulated buses during heavy traffic.

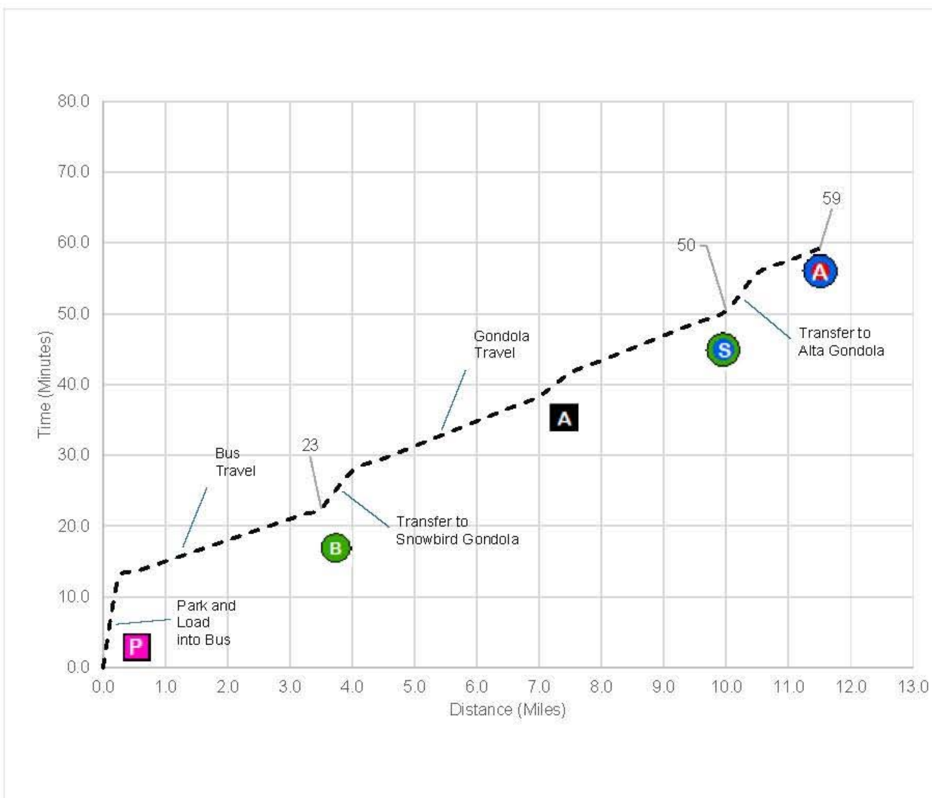
What would be the total travel time to Snowbird and Alta with Scenario 4B?

With Scenario 4B, the total travel time would be about 50 minutes to Snowbird and about 60 minutes to Alta.

Including the transfer from bus to gondola, the total travel time would be about **50 minutes to Snowbird** and about **59 minutes to Alta** (Figure 7). However, if buses are operating on a two-lane 9400 South in mixed traffic (both personal vehicles and buses), slower average speeds are expected.

Note that this travel time does not include the travel time from the starting point, Wasatch Boulevard and Fort Union Boulevard. Therefore, a direct comparison to Scenarios 1, 2, and 3 is not appropriate.

Figure 7. Scenario 4B Map and Travel Time Graph



5.4.3 Cost Estimate

Scenario 4A – Complete Gondola Alignment

Capital Cost

Scenario 4A would be a complete gondola alignment from 9400 South and Highland Drive to the mouth of the canyon. UDOT has assumed a mode shift (from bus to gondola) at the mouth of the canyon requiring four total terminal stations and seven total angle stations. The total length of the alignment would be 11.5 miles. The rough order-of-magnitude capital cost estimate is broken down by component in Table 11. The total capital cost would be about $438,240,000. Note that this cost does not include right-of-way costs, residential relocation costs, or costs to relocate existing infrastructure.

Table 11. Scenario 4A Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	11.5 miles	18,000,000	207,000,000
Terminal stations	4 stations	11,000,000	44,000,000
Resort interface for terminal stations	4 stations	6,000,000	24,000,000
Angle stations	7 stations	10,200,000	71,400,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Enhanced bus service capital	1 lump sum	NA	NA
Total Low Estimate			**398,400,000**
Contingency (10% of low estimate)	—	—	39,840,000
Total High Estimate			**438,240,000**

Annual O&M Cost

The annual O&M cost for Scenario 4A would be similar to that for Scenario 3A. Scenario 4A has a slightly shorter gondola alignment than does Scenario 3A. Using the per-mile unit cost for some of the gondola O&M categories would result in a slightly lower cost for Scenario 4A. However, the additional angle stations and equipment for Scenario 4A would likely more than offset the annual O&M cost savings of this shorter gondola alignment. UDOT estimates that the total rough order-of-magnitude cost to operate Scenario 4A would be about $$4,337,000 to $4,770,700 annually.

Scenario 4B – Express Bus to Gondola Alignment

Capital Cost

Table 12 presents the rough order-of-magnitude capital cost for Scenario 4B. This scenario uses the same bus capital assumptions as for Scenario 3B. Using buses to move people to the mouth of Little Cottonwood Canyon would cost about $126 million less than would using a gondola over the same distance.

Table 12. Scenario 4B Capital Cost Estimate

Component	Units	Cost per Unit ($)	Component Cost ($)
Lift system	8.3 miles	18,000,000	149,400,000
Terminal stations	3 stations	11,000,000	33,000,000
Resort interface for terminal stations	3 stations	6,000,000	18,000,000
Angle station	1 station	10,200,000	10,200,000
Parking	2,500 stalls	64.77/square foot	52,000,000
Enhanced bus service capital	1 lump sum	21,000,000	21,000,000
Total Low Estimate			**283,600,000**
Contingency (10% of low estimate)	—	—	28,360,000
Total High Estimate			**311,960,000**

Annual O&M Cost

The annual O&M cost for Scenario 4B would be similar to that for Scenario 3B. UDOT assumes that the same number of buses would be needed to transport passengers from the 9400 South and Highland Drive mobility hub to the mouth of the canyon. Major roadway improvements to 9400 South, which are not included in this scenario, would be required to help buses operate along this route. Scenario 4B would have a total rough order-of-magnitude O&M cost of about $4,073,000 to $4,543,000 annually.

Assuming the same modified bus schedule and capacity shown in Table 9 for Scenario 3B, UDOT estimates that the rough order-of-magnitude O&M cost for Scenario 4B would be about $3.8 million to $4.2 million annually.

6.0 Comparison of Concepts

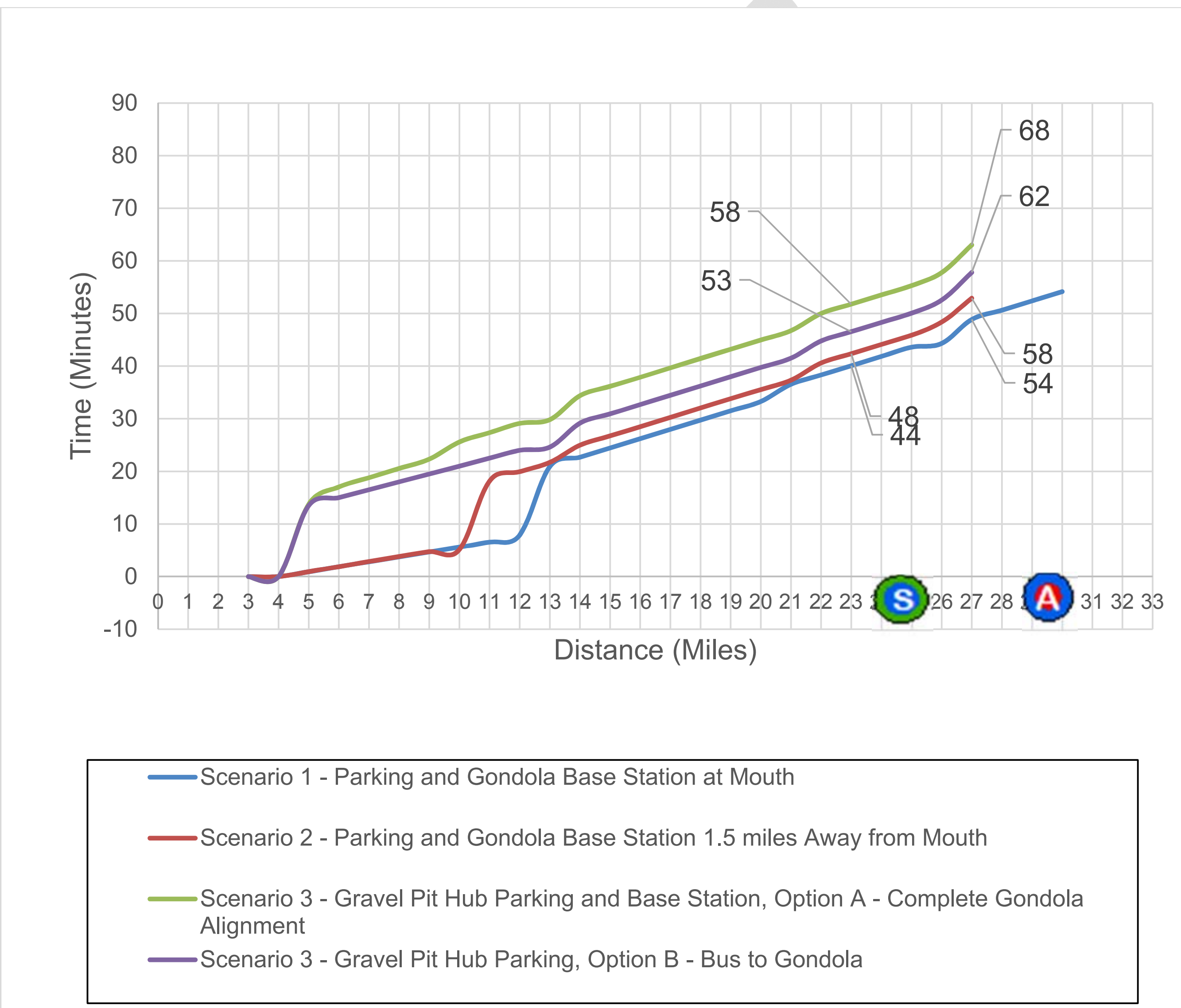
Taking into account the details of each scenario as described in Section 5.0, Parking, Base Station, and Gondola Alignment , UDOT compared the scenarios using the major initial feasibility criteria of travel time and capital and O&M costs. UDOT also compared the scenarios using the additional feasibility criteria of the purpose of the Little Cottonwood Canyon Project as well as specific considerations that apply to gondolas in an urban environment.

6.1 Comparisons Using the Major Feasibility Criteria

6.1.1 Travel Time

Figure 8 compares the cumulative travel times for scenarios that use or parallel Wasatch Boulevard. Figure 8 also shows the total estimated travel times from Fort Union Boulevard to Snowbird and Alta for Scenarios 1, 2, 3A, and 3B.

Figure 8. Travel Time Comparison for Scenarios 1, 2, 3A, and 3B



With the assumptions used in this initial feasibility study, the fastest overall travel times to the resorts in a gondola would occur with an expanded parking area and base station near the mouth of Little Cottonwood Canyon. Moving the parking away from the canyon, to Wasatch Boulevard and Fort Union Boulevard or to the mouth of Big Cottonwood Canyon, would add about 9 to 14 minutes to the total travel time.

Figure 9 presents a cumulative travel time graph for the 9400 South and Highland Drive mobility hub scenarios (Scenarios 4A and 4B). If roadway and bus operating conditions could allow a 20-mph average bus speed, Scenario 4B would result in faster travel times than would a complete gondola alignment from this mobility hub.

Figure 9. Travel Time Comparison for Scenarios 4A and 4B

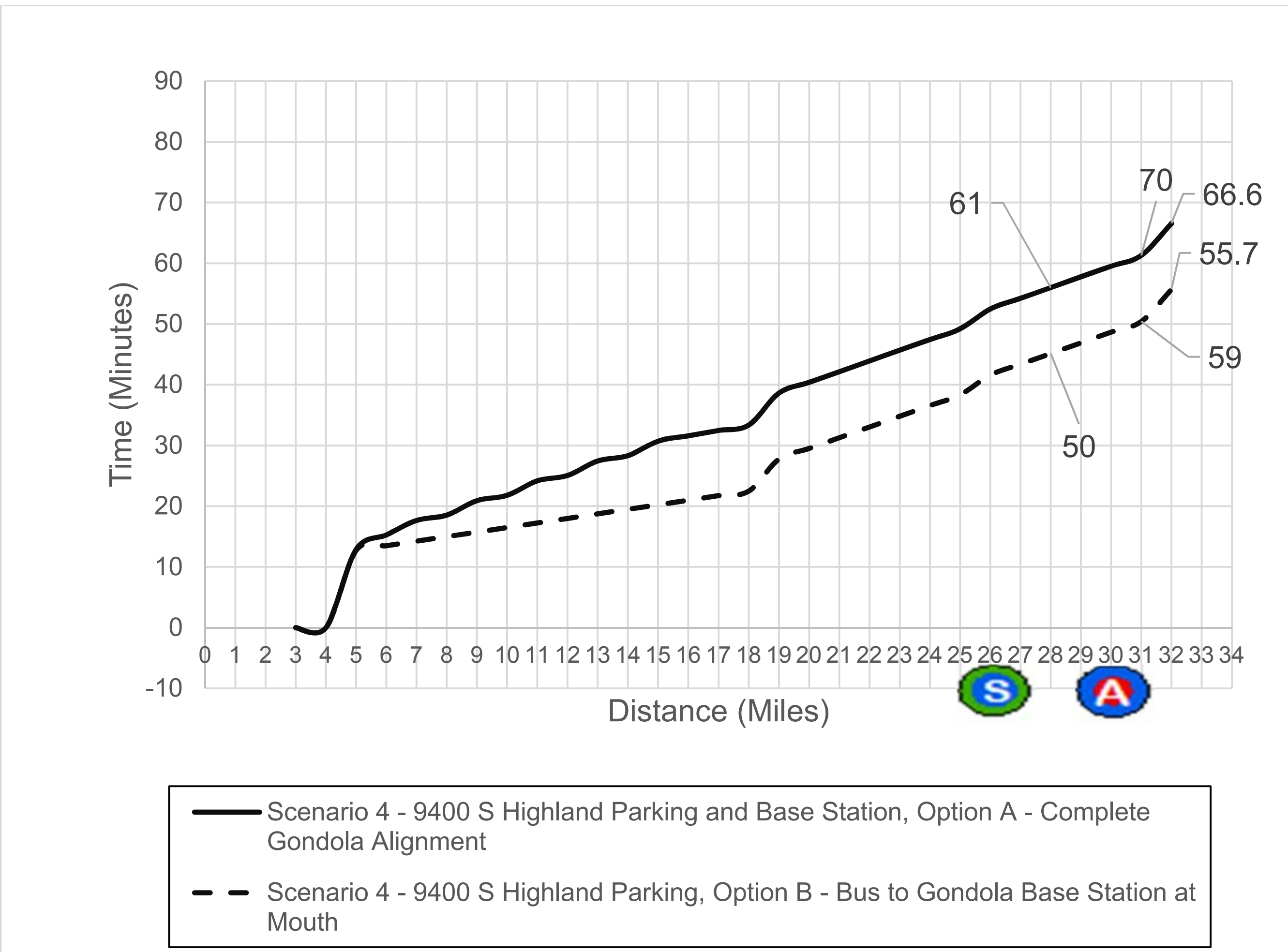


Table 13 summarizes the gondola segments and travel times for the scenarios presented in Section 5.0, Parking, Base Station, and Gondola Alignment Scenarios.

Table 13. Gondola Travel Time Comparison

Scenario	Bus Segment (miles)	Gondola Segment (miles)	Travel Time to Snowbird (minutes)	Travel Time to Alta (minutes)
1	0.0	8.3	44	54
2	0.0	9.8	48	58
3A	0.0	12.5	58	68
3B	4.2	8.3	53	62
4A	0.0	11.5	61[a]	70[a]
4B	3.5	8.3	50[a]	59[a]

[a] Travel time does not include a personal vehicle trip in the segment from Wasatch Boulevard and Fort Union Boulevard to a mobility hub at 9400 South and Highland Drive.

The travel time for Scenario 3A would be about 14 minutes longer than for Scenario 1, which would place both the parking structure and the base station at the mouth of the canyon. The travel time for Scenario 3B would be about 8 minutes longer than for Scenario 1. Scenario 3A would have travel times 6 minutes longer than Scenario 3B. Using express, high-capacity buses from the gravel pit mobility hub (Scenario 3B), travel times would be about 8 minutes longer compared to personal vehicle travel and gondola transit in the canyon (Scenario 1).

6.1.2 Capital and Annual O&M Costs

Table 14 presents a comparison of the capital and annual O&M costs for each scenario.

Table 14. Gondola Capital and Annual O&M Cost Comparison

In millions of dollars

Scenario	Capital Cost	Annual O&M Cost	
		With Original Bus Schedule	With Modified Hourly Bus Schedule
1	262.6 – 288.6	3.1 – 3.5	NA
2	299.8 – 329.7	3.1 – 3.5	NA
3A	375.6 – 413.2	4.3 – 4.8	NA
3B	312.2 – 343.4	4.1 – 4.5	3.8 – 4.2
4A	398.4 – 438.2	4.3 – 4.8	NA
4B	312.2 – 343.4	4.1 – 4.5	3.8 – 4.2

The biggest capital cost drivers are the length of the gondola alignment and the need for more terminal and angle stations (and their required infrastructure). Comparing Scenario 1 to Scenario 3A, it would cost about $124 million more to construct a gondola alignment running from the mobility hub at the gravel pit to a base station at the mouth of Little Cottonwood Canyon than to construct a parking structure and base station at the mouth of the canyon.

Constructing a parking structure at the mouth of Little Cottonwood Canyon might not be feasible for several reasons: it might cause traffic delays at the intersection of S.R. 210 and S.R. 209, there might not be enough space to construct a parking facility at the base of the canyon, it might cause traffic congestion for residents entering and leaving their neighborhoods, and there might be public opposition. If constructing a parking structure at the mouth of the canyon is not feasible, it might be more cost-effective from a capital cost perspective to use buses to access the gondola base station at the mouth of the canyon for passenger loading and unloading. This approach would also result in shorter overall travel times.

Comparing the Scenario 3 options, Scenario 3A would cost about $101.2 million more to construct (capital cost) than would Scenario 3B. Scenario 3B ($4.5 million) would also have slightly lower O&M costs than would Scenario 3A ($4.8 million) if buses were used in the urban segments. Other scenarios that use only a gondola would have annual O&M costs of about $3.5 million (Scenarios 1 and 2) to $4.8 million (Scenario 3A).

Comparing the Scenario 4 options, using buses in the urban segment of 9400 South (Scenario 4B) could save about 11 minutes of travel time compared to a complete gondola alignment (Scenario 4A). In addition, Scenario 4A would cost almost $126 million more than Scenario 4B. More analysis would be required in order to more accurately determine the roadway, shoulder, and intersection improvements needed to maintain the assumed bus speeds with Scenario 4B. The O&M costs to operate both the gondola system and a bus fleet with Scenario 4B would be about $4.5 million compared to $4.8 million annually for Scenario 4A, which is a gondola-only option.

The annual O&M costs would comparable (at about $3.8 million to $4.8 million annually) for all scenarios (3A, 3B, 4A, and 4B) where parking would be located away from the mouth of Little Cottonwood Canyon. Annual O&M cost might be slightly lower, about $0.6 million, if the bus schedule were optimized to better match the expected hourly demand.

6.2 Comparisons Using Additional Feasibility Criteria

In addition to comparing the scenarios in terms of their travel time and capital and O&M costs (Section 6.1), UDOT also compared the scenarios in terms of feasibility criteria pertaining to the purpose of the Little Cottonwood Canyon Project (improved mobility and improved neighborhood access). UDOT also included feasibility criteria pertaining to residential impacts and privacy issues, which are considerations that apply to gondolas in an urban environment. Other environmental impacts would be addressed in the EIS if a gondola concept is selected for detailed analysis. These additional feasibility criteria are described below, and the scenarios' ratings for these criteria are summarized in Table 15.

- **Impacts to Congestion.** Improving mobility is an element of the Little Cottonwood Canyon Project's purpose because traffic backs up at the intersection of S.R. 210 and S.R. 209 and clogs residential neighborhoods. In Table 15, impacts to traffic congestion represent the effect on the surrounding area. For example, Scenarios 1 and 2 would not change the existing travel patterns and so are rated as having a high impact for this comparison criterion. In contrast, Scenario 3 would keep traffic near the existing interstate (I-215), near higher-capacity existing roads, and next to existing commercial areas, and is therefore rated as having a low impact.
- **Needed Roadway Improvements.** This criterion qualitatively captures the degree of roadway improvements needed to provide priority travel for buses and needed infrastructure improvements near the mobility hub for efficient access to parking. Scenarios 3A and 3B are rated as having a low impact for this criterion because existing infrastructure near the gravel pit mobility hub can accommodate the expected traffic, and planned improvements to Wasatch Boulevard will help bus travel. Scenarios 1 and 2 are rated as having medium impacts because some roadway improvements would be needed near the parking structure in this more-residential area. Scenario 4B would require significant improvements from 9400 South and Highland Drive to the mouth of the canyon in order to maximize bus travel times. Therefore, Scenario 4B is rated as having a high impact for this criterion.
- **Residential Impacts.** UDOT assumes that owners of residences directly under the gondola's airspace would need to be relocated. A low impact is assigned for this criterion for scenarios that have gondola alignments in the rural segments only (Scenarios 1, 3B, and 4B). A high impact is assigned for scenarios that have gondola alignments in the urban segments (Scenarios 3A and 4A).
- **Privacy Concerns.** This criterion looks at the general number of homes that would be adjacent to the gondola alignment within view of gondola riders in the gondola cabin. Because the cabins would be elevated 100 to 200 feet in the air, privacy would be a concern for residents beyond the areas immediately adjacent to the gondola alignment. There is a large amount of residential development along Wasatch Boulevard and 9400 South. Like the residential impacts criterion, a low impact is assigned for this criterion for scenarios that have gondola alignments in the rural segments only (Scenarios 1, 3B, and 4B), and a high impact is assigned for scenarios that have gondola alignments in the urban segments (Scenarios 3A and 4A). For the scenarios in which the base station is located away from the mouth of Little Cottonwood Canyon, UDOT expects the public to strongly oppose these scenarios due to these privacy concerns.

Table 15. Comparison of Additional Feasibility Criteria

Scenario	Impacts on Traffic Congestion	Needed Roadway Improvements	Residential Impacts	Privacy Concerns
1	High	Medium	Low	Low
2	High	Medium	Medium	Medium
3A	Low	Low	High	High
3B	Low	Low	Low	Low
4A	Medium	Low	High	High
4B	Medium	High	Low	Low

Comparing these rankings, Scenario 3B has the lowest impact across the four additional feasibility criteria presented in this section. Scenario 3A is better than Scenario 1 from the standpoints of traffic congestion and needed roadway improvements, but implementing Scenario 3A would be challenging because of potentially high residential impacts and privacy concerns.

Table 16 summarizes all of the comparison criteria for the scenarios presented in this report.

Table 16. Comparison of Costs, Travel Times, and Additional Feasibility Criteria

Scenario	Capital Cost (million $)	Annual O&M Cost (million $)	Total Travel Time to Alta (minutes)	Impacts on Traffic Congestion	Needed Roadway Improve-ments	Residential Impacts	Privacy Concerns
1	262.6 – 288.6	3.1 – 3.5	54	High	Medium	Low	Low
2	299.8 – 329.7	3.1 – 3.5	58	High	Medium	Medium	Medium
3A	375.6 – 413.2	4.3 – 4.8	68	Low	Low	High	High
3B[a]	312.2 – 343.4	4.1 – 4.5	62	Low	Low	Low	Low
4A	398.4 – 438.2	4.3 – 4.8	70[b]	Medium	Low	High	High
4B[a]	312.2 – 343.4	4.1 – 3.5	59[b]	Medium	High	Low	Low

[a] Annual O&M cost for Scenarios 3B and 4B would be about $3.8 million to $4.2 million with a modified bus schedule (see Table 9).

[b] Travel time does not include a personal vehicle trip in the segment from Wasatch Boulevard and Fort Union Boulevard to a mobility hub at 9400 South and Highland Drive.

6.3 Considerations for Implementing ATS in Little Cottonwood Canyon

General engineering and operational considerations were provided in Section 4.0, General Considerations for Implementing a 3S Gondola System. Additional implementation considerations include the following:

- Peak demand periods occur for about 2 or 3 hours during the winter in the morning and evening (4 to 6 hours total) over about 68 weekend days and holidays. For the majority of the winter season, the gondola could be operating at less than maximum capacity. Canyon visitors might not use the gondola as frequently during off-peak times and on weekdays, when there is generally less congestion and adequate parking available, because gondolas would have longer travel times to the resorts compared to automobiles.
- Gondolas would have a limited ability to serve dispersed summer recreation in the canyon. In order to maintain reasonable travel times for the long gondola ride during the highest demand periods (winter weekends), few intermediate terminals and few turns (requiring angle stations) should be added to the gondola alignment. For the long distances needed to reach the resorts (8 to 12 miles), gondola cabins need to stay on the haul cable as much as possible. Adding stations at trailheads for summer use (when peak-hour demands are lower) would slow the gondola during times of peak demand.
- The scenarios were sized to accommodate the peak-hour total travel demand (about 1,000 people per hour). Bus service can be adjusted to better match expected hourly ridership by adjusting the days of the week and the times of the day when services are provided. This would save some O&M costs. Gondolas, on the other hand, need to be designed to handle the higher hourly demands so that they are attractive to riders during these periods. However, gondola operations cannot be easily adjusted during lower-demand periods, so the O&M costs for gondolas are fixed unless the gondola is shut down.
- The annual ridership of a gondola system, measured as a percentage of total trips in the canyon, would be low without other traffic-demand-management tools (such as tolling) or an overall policy to significantly restrict personal vehicles in the canyon. The resulting gondola fare needed to pay back the capital cost and fund operating expenses was not determined for this initial feasibility study. UDOT is conducting an analysis to understand canyon users' willingness to pay for transit service versus the value of their time (ridership elasticity) and will apply those findings in the ongoing alternatives evaluation process for the EIS.

7.0 References

CH2M

2018 Burnaby Mountain Gondola Transit Feasibility Study. April.

Fehr and Peers

2012 Mountain Transportation Study. Prepared for Salt Lake County. November.

Jacobs Engineering Group

2016 Aerial Cable Transit Feasibility Study, Final Report. Prepared for the Miami-Dade Metropolitan Planning Organization. February.

Leitner-Poma

2018 "Little Cottonwood Canyon 3S." Email from Daren Cole, Leitner-Poma, to Terry Warner, HDR, Inc. September 5.

Mountain Accord

2017 Mountain Accord Cottonwood Canyons Long-term Transportation Solutions, Technical Memorandum. May.

Parsons Brinkerhoff, Doppelmayr, and Kleinfelder

2015 San Diego Bay to Balboa Park Skyway Feasibility Study. Prepared for the San Diego Association of Governments. June 19, 2015

[UTA] Utah Transit Authority

2019 Comprehensive Annual Financial Report for Fiscal Years Ended December 31, 2018 and 2017. June.

WSP/Parsons Brinkerhoff

2017 Sorrento Valley Skyway Feasibility Study. Prepared for San Diego Association of Governments. January.

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