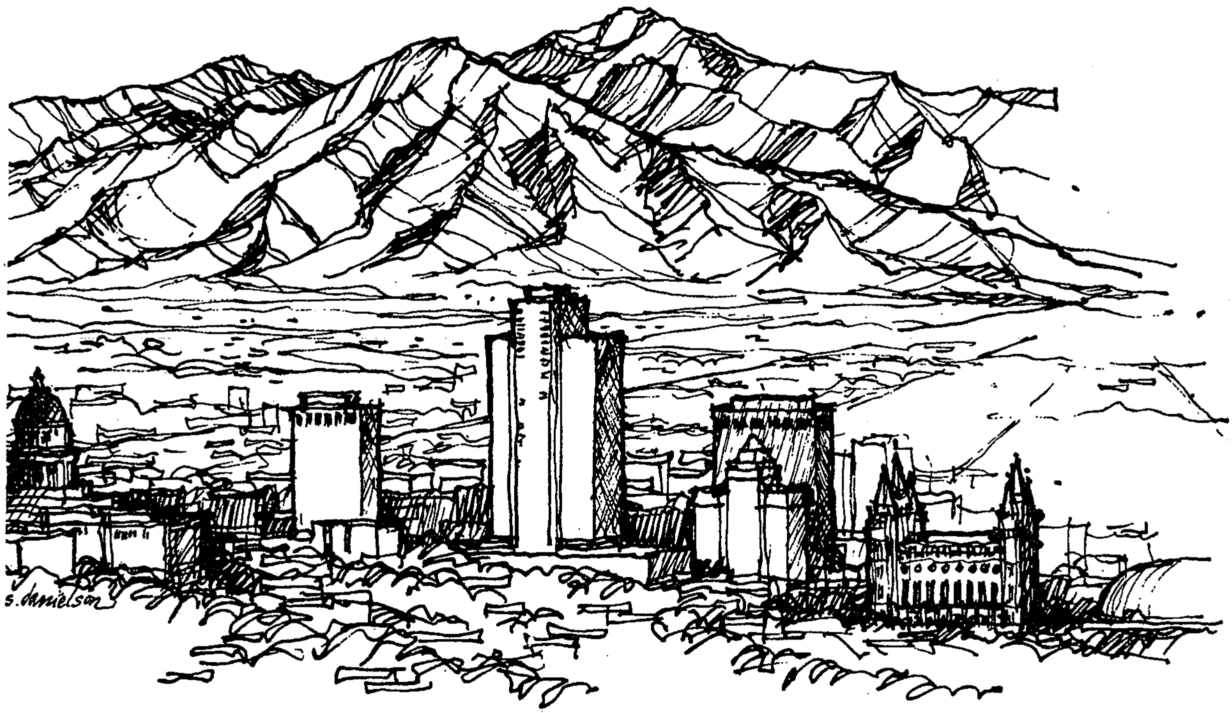

Wasatch Canyons Transportation Study

LONG-RANGE TRANSPORTATION CONCEPTS FOR THE WASATCH CANYONS RECREATIONAL AREAS

Wasatch Front Regional Council

FEBRUARY 1977

WASATCH CANYONS TRANSPORTATION STUDY

LONG-RANGE TRANSPORTATION CONCEPTS

FOR

THE WASATCH CANYONS RECREATIONAL AREAS

Prepared for the

WASATCH FRONT REGIONAL COUNCIL

AND

SALT LAKE COUNTY

Prepared by

PBQ&D, INC.
Santa Ana, California
under contract to VTN Consolidated, Inc.

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CONTENTS

FOREWORD

The Wasatch Canyons Transportation Study is a cooperative effort between the Wasatch Front Regional Council and the County of Salt Lake. The Study is funded in part by the Urban Mass Transportation Administration, U. S. Department of Transportation, with local matching funds and Study coordination provided by Salt Lake County. Cooperating agencies include the Salt Lake County Planning Commission, the Salt Lake County 208 Project, the U. S. Forest Service, the Utah State Department of Transportation, the Town of Alta, and numerous other local, regional, and statewide agencies and organizations. The Study is being coordinated by Salt Lake County as part of the continuing planning process for the Canyons of the Wasatch Front. Project consultant is PBQ&D, Inc., Santa Ana, California, under contract to VTN Consolidated, Inc.

INTRODUCTION

This report is the final document in a series of Working Papers and Technical Reports for the Wasatch Canyons Transportation Study. As a portion of the overall Salt Lake County effort designed to develop guidelines and plans for the Canyons of the Wasatch Front, this Transportation Study is being conducted simultaneously with other programs investigating land use, future growth, and water quality in the Canyons.

The Wasatch Canyons Transportation Study has been structured in three phases:

- Immediate Action Plan
- Short-Range Improvement Plan
- Long-Range Development Concept

This report summarizes the recommendations for long-range transportation planning and program development for the major recreation areas of the Wasatch Canyons in Salt Lake County. The Immediate Action Plan, stressing transportation improvement strategies for 1975-1976, has been completed and the recommendations have been implemented to the extent possible. The Short-Range Program, submitted in November, 1976, was designed to build systematically on the recommendations for immediate action in order to develop a staged plan for transportation improvements in the Canyons, based on expected patterns of growth, land use, recreational participation, and Canyon development. The Short-Range Improvement Plan included recommendations for the period 1976-1977 through 1980-1981, and implementation of transit-related programs was initiated during the 1976-1977 ski season in Big and Little Cottonwood Canyons.

The Long Range Development Plan is designed to be a conceptual guide to possible Canyon transportation improvements in a time frame beyond five years. As such, recommendations are based on assumptions regarding future Canyon growth, development, land use, and recreational participation. Recommendations for capital-intensive transit system development should be thought of as alternatives to the extensive "bus-in-mixed-traffic" plans recommended for the next five years. Thus, such long-range alternatives may be applicable if the bus system proves unworkable due to problems of capacity, safety, cost-effectiveness, and/or environmental degradation. This report provides recommendations regarding the type of transit system which could best succeed the bus-in-mixed-traffic system should a higher capacity alternative become desirable.

GUIDELINES FOR LONG-RANGE TRANSPORTATION PLANNING IN THE WASATCH CANYONS

Background and Time Frame

The long-range transportation planning concepts for the Wasatch Canyons are set in a time frame beyond the year 1981. Since transportation system development, land use, and recreational development are so intimately linked in the Canyon setting, long-range transportation recommendations are geared to possible growth, development, and use scenarios rather than tied specifically to a calendar-based schedule of implementation. In this way, at such time as the staged bus transit program developed and submitted in the Short-Range Plan (1977-1981) becomes unworkable due to capacity constraints, cost, environmental conditions, or other problems, the longer-term recommendations described in this report may be considered for specific system refinement and implementation in the Wasatch Canyons.

It is important to understand that possible solutions to transportation problems suggested in the long-range context may never become warranted, depending to a large extent upon their direct cost-effectiveness and upon future plans of the Canyon resorts, the Town of Alta, and Salt Lake County with respect to recreational, commercial, and residential growth in the Canyons. It should also be understood that possible extensions, modifications, or changes in the Canyon bus services recommended in the Short-Range Program may effectively serve long-range transportation demands generated by future Canyon land uses. Finally, it should be understood that transportation facilities and services available in the future may, in fact, be the key to future Canyon development. In this context, critical policy decisions on the part of the relevant public agencies will be necessary regarding the levels of public versus private expenditure for Canyon transportation facilities required to support desired levels of Canyon development.

Alternative Scenarios for Canyon Development and Use

Long-range improvement recommendations for Wasatch Canyons transportation services focus on the Cottonwood Canyons and, particularly, Little Cottonwood Canyon. With the possible exception of the Alta/Snowbird region, it is not anticipated at this time that future development beyond 1981 in any of the Wasatch Canyons will be of a level consistent with capital-intensive, high capacity transit system implementation.

Recent figures from Snowbird Corporation indicate that Snowbird's present Forest Service permit area can accommodate some 700,000 annual skier-visits, or 4,400 skiers on an average daily basis. Projections through 1981 indicate the following annual skier-days at Snowbird:

Year	Projected Annual Skier Days
1977-78	350,000
1978-79	382,000
1979-80	444,000
1980-81	476,000

The ultimate capacity of 700,000 annual skier-days would be reached in 1986 according to the percentage rate of increase for the above projections. However, this capacity may not be reached until 1990 or beyond, since the rate of increase will begin to decline in 1981 subsequent to the completion of four additional chairlifts. These new chairlifts, to be built in 1978-1980, will have the effect of essentially doubling Snowbird's 1975 lift capacity to over 13.5 million VTF (vertical transfer feet). Additional lodging and convention facilities will also be completed within the next five years.

The rate of growth of lodging and lift facilities in the Town of Alta has not been well defined within the context of the long-range plan. However, it is understood that additional chairlifts may be planned for the Albion Basin area. Growth of overnight facilities is not known at this time, but little if any such development is anticipated in the Town of Alta beyond current levels.

Recreational, commercial, and retail growth in the other Canyons along the Wasatch Front is expected to occur, but at a very low level as dictated by the environmental carrying capacities of the respective Canyon environments. Such growth is not anticipated to be anywhere near the magnitude which would create serious transportation-related problems.

There would appear to be three basic scenarios regarding long-term future growth and development in the Cottonwood Canyons and adjacent recreational use areas. These scenarios might be defined as follows:

(1) Low to moderate growth in ski and lodging capacity in Big and Little Cottonwood Canyons, somewhat below the levels of skier-days projected by Snowbird and the Utah Ski Association. Such a scenario might result from the combination of a number of factors, including decreased recreational demand, increased environmental pressures, or future economic conditions.

(2) Significant growth in both overnight facilities and mountain capacity, with winter and summer use both experiencing sizeable increases over present levels. Annual skier-day increases would approximate 10 percent per year, in keeping with or slightly above Snowbird's projections. Each major area--Big Cottonwood Canyon (Brighton, Solitude), Little Cottonwood Canyon (Alta, Snowbird), and Park City--would continue to be essentially "isolated" from the others.

(3) Major expansion of all-year facilities in the Cottonwood Canyons and at Park City, with an attempt to physically link the areas by some form of transportation.

It is clear that long-range transportation development strategies may vary, depending upon the events that occur in the Canyons and the extent to which such events approximate these three basic future scenarios. The major objective of this report will be to recommend appropriate long-range transportation programs to respond to the range of possible future conditions in the Canyons, as represented by the above-listed scenarios.

TRANSPORTATION MODES AND TECHNOLOGIES: AN OVERVIEW

Transportation Alternatives for the Wasatch Canyons

There are three basic classes of transportation systems which would appear to have potential merit for future development in the Cottonwood Canyon setting. Criteria for the acceptability of these classes of systems include cost, environmental impact, Canyon capacity requirements, and performance characteristics. These three basic alternatives are as follows:

1. Buses Operating in Mixed Traffic. This mode is basically the present system as recommended in the Short-Range Program. It consists of scheduled buses serving the Canyon destinations from various points in the region, and operating on existing roads in "mixed traffic" with private automobiles and other vehicles. Long-range travel demand projections based on future Canyon development and use would determine the required levels of service and route structure for this type of bus system. Of course, increased Canyon travel demands beyond the immediate five-year time frame could dramatically alter the magnitude and nature of bus service.

2. Buses Operating on Busways or on Existing Roads with Automobile Restrictions. This alternative can increase the ultimate capacity of up-Canyon destinations without the necessity to increase road capacity or parking availability at the resort areas. The least capital-intensive approach would be to simply use existing Canyon roads, where warranted, as exclusive busways by restricting private automobile use through employment of remote parking facilities. A much more expensive option--both in terms of physical and financial resources--would be to construct busways roughly parallel to existing roads.

3. Fixed Guideway Systems. This final alternative includes a number of specific transit technologies which employ fixed guideway facilities, including: cable systems, at-grade rail systems, and above-grade suspended or supported rail systems. This alternative obviously embraces the most capital-intensive systems, although once in place, operational and maintenance costs associated with these systems could be equivalent to or less than more labor-intensive bus systems.

Candidate Transportation Systems

Bus system technology is relatively well known and its application to the Cottonwood Canyons was described fully in the Short-Range Plan report. Various types of fixed guideway systems have received a great deal of previous study with respect to implementation in Little Cottonwood Canyon by consultants, students, public agencies, and concerned special interest groups. However, for purposes of description and definition, the following sections of this report review several applicable fixed guideway technologies, including: monorail, automated guideway transit, personal rapid transit, cable systems, and cog-assisted railways. Each of these fixed guideway transit systems is reviewed in terms of general system descriptions, status of development, applications, performance characteristics, and cost characteristics.

MONORAIL SYSTEMS

Description

Two basic classes of monorail can be identified. If the passenger compartment is located above the support structure, it is referred to as a "bottom supported," or supported monorail; if the passenger compartment is below the support structure, it is called a "top supported," or more commonly a suspended monorail.

Monrails always seem to have had great popular appeal to the public. Most transportation engineers have rejected them for urban transportation applications, although several installations have been made in amusement parks, zoos, and expositions, where the novelty has marketing advantages. The reason for this rejection is that monorail proposals of the past have involved designs where there are no major advantages over duorail trains, except for somewhat less bulk in aerial structures. This advantage is usually offset by greater complexity of running gear, poorer ride quality at speeds of interest for urban transit, greater overall height requiring larger tunnel cross sections, and switching and yard problems.

To some engineers the very term monorail is a misnomer, as the running gear is not operated on a single rail, but on a number of surfaces on a rather large beam, and so perhaps the term should be "monobeam." To some extent this is semantic hair splitting, but it is important to realize that the beam, or support structure, is not a delicate object with small dimensions. The beam of the Hitachi-Alweg supported monorail, for example, has a height of 1.88 meters (6.17 feet) and a width of .87 meters (2.85 feet). This is a continuous structure with serious visual impact if in an aerial location; if it is on the surface it presents a concrete wall to passage of any cross traffic.

Status of Development and Applications

This subsection describes the status of monorail development in terms of specific systems and installations. Suspended monorail systems are discussed first and then supported monorails. Performance characteristics vary greatly between systems, so these are presented by indivudal system or installation.

Suspended Monorails

Monorails of both supported and suspended types have gone through the prototype and development stages into revenue service during the past decade. The tabulation below describes some of the more significant installations of the suspended type:

Name	Location	Length	Type	Support Technology	Line Speed	Remarks
Shohan	Between Ofuna and Katase, Japan	23,000 ft.	Suspended	Rubber Tires	47 MPH	SAFEGE type, built by Mitsubishi
Wuppertal	Wupper, Germany	49,000 ft.	Suspended	Steel Wheel	25 MPH	Built in 1900; in revenue service since then; uses steel wheels
URBA	Lyon, France	14,500 ft.	Suspended	Air Cushion	34 MPH	Prototype; uses air suction for suspension
Jet Rail	Love Field, Texas	8,000 ft.	Suspended	Rubber Tires	10 MPH	Operated by Braniff to connect parking lot to terminal

Universal Mobility

Universal Mobility, Inc., located in Salt Lake City, is the U. S. arm of the Habegger Engineering Works in Thun, Switzerland. It markets a system called "Unimobile/Habegger," which is a small bottom supported monorail using rubber tires. This is called "Unimobil." The firm has been highly successful in marketing these systems, and has installed a number in zoos, parks, and recreational areas. These are low speed, moderate capacity devices typically around 10 to 12 mph and in the range of 2000 to 6000 passengers per hour, one way. With support column spacing of 60 feet, in a typical installation, the steel guideway is 22 inches deep and 30 inches wide, thus lending some credence to the idea of light aerial structures for monorails.

Supported Monorails

The ALWEG system was developed in Germany by Dr. Axel Leonart Wenner-Gren, from which it takes it's name, who developed first a reduced scale and then a full scale prototype in 1957. The further development and implementation of this system on a significant scale fell to Hitachi Ltd., which signed a technical cooperative agreement with ALWEG in 1960. A number of installations of this system, tabulated in chronological sequence, are given in the table below:

MONORAIL INSTALLATIONS

Location	Completed	Line Length	Track Configuration
Fuhlingen (West Germany)	1957	1.1 miles	Single track
Disneyland	1959	.9 miles	Single track
Disneyland	1961	1.6 miles	Single track
Turin	1961	.7 miles	Single track
Inuyama	1962	.9 miles	Single track
Seattle	1962	1.0 miles	Double track
Yomiuri-land	1963	1.2 miles	Single track
Yomiuri-land	1964	.7 miles	Single track
Haneda-Tokyo	1964	8.2 miles	Double track

The most significant of these installations is probably the Hitachi-ALWEG line from Haneda Airport to downtown Tokyo; this has 8.2 miles of two-way track, and has 14 stations. Although almost all of the system is aerial, a portion is in tunnel (Ebitori), and at the airport. At the tunnel entrance to Haneda, the line is on-grade. Specific data regarding this system is provided in the table on the following page.

HITACHI-ALWEG MONORAIL SYSTEM SPECIFICATIONS

General Data

No. of seats	104
Maximal passengers	240
Crush load	N/A
Cars in train	2

Dimensions

Length over couplers	96'5-1/2"
Width Maximal	10'0"
Height	
Maximal over roof	14'1-5/8"
Maximal headroom	7'2-5/8"

Weights

Pounds per car	81,360
Pounds per feet	843
Pounds per seat	782

Motors

Number	4
Type	DC Series
Horsepower	
Per motor	175
Per car	700
Per ton, empty	17.2

Performance

Maximal acceleration	1.7 mph/second
Maximal speed	62.5 mph
Braking rate	2.8 mph/second

Trucks

Wheel base	N/A
Gear ratio	8.355:1
Minimal horizontal curvature	385'
Wheel centers	24'3-3/8"
Maximal grade	6%

AUTOMATED GUIDEWAY TRANSIT SYSTEMS

Automated Guideway Transit (AGT) is a class of transportation systems in which unmanned vehicles are operated on fixed guideways along an exclusive right-of-way. The capacity of the vehicles may range from one or two up to 100 passengers. Single units or trains may be operated. Speeds range from 10 to 40 miles per hour. Headway capabilities vary from one or two seconds up to a minute. These systems may involve a single route or branching and interconnecting lines. AGT encompasses a large class of systems with a broad range of characteristics including many types of technology. One of the subcategories of AGT is Personal Rapid Transit (PRT) which is discussed in another section. The remaining systems of the AGT class are the subject of this section. These systems are classified into two groups: AGT-I and AGT-II.

Since systems in each group are either still at the conceptual planning stage or in the demonstration state and little actual operating experience is available, performance and cost characteristics are subject to potential variations and cannot be accurately defined for the classes as a whole. Thus, the performance and cost characteristics described here pertain to specific systems and may not be appropriate for similar system types. Presentation of performance and cost characteristics on the basis of individual systems or installations has necessitated some modification of format for this section. AGT-I and AGT-II systems are presented separately and Status of Development, Example of Application, Performance Characteristics, and Cost Characteristics are all discussed by individual system or installation under the subheading, Status of Development and Applications.

AGT-I Systems

Description

Some of the U. S. manufacturers now in the transit field started out to develop and market PRT systems. Higher development costs and marketing problems led to design compromises reflected in larger vehicles and space for standees, increases in headways to a range of 5 to 15 seconds, and a determination to market simpler systems in terms of scale and network complexity. This group of automated guideway transit systems is identified as AGT-I systems. These systems have many attributes in common with PRT, namely:

- Smaller units than mass transit, typically 10 to 25 passengers per unit, but operated as single units and not in trains
- Exclusive guideway operation
- Fully automatic control, with typical headway of 5 to 15 seconds
- Off-line stations, or at least rapid switching capacity

This type of AGT system is interesting because the units are small and off-line stations are used so that demand responsive operation can be used at least part of the day. The shorter headways, rapid switching, and off-line operation distinguish these systems from the AGT-II systems, which are simply small scale mass transit systems. The AGT-I systems are precursory PRT systems since the technology can be upgraded at a later date if desired to achieve shorter headways, and more demand responsiveness; and a smaller vehicle might be introduced to match the shorter headways.

Status of Development and Applications

Boeing/Morgantown. The Boeing Company has designed and built an AGT system of this type at Morgantown, West Virginia, where 3.52 km (2.2 miles) of two-way track connect non-contiguous compuses of West Virginia University and the town of Morgantown. The present system uses 45 rubber-tired vehicles with 8 seated and 7 standing passengers (up to a total of 21 with crush loading). There are three stations, all off-line, and the operation uses a combination of demand and scheduled modes. The system is expected to carry 29,500 passengers daily. (For comparison, the BART system in the San Francisco area is carrying about 120,000 daily rides.)

The Morgantown system has been in operation since October, 1975, and in May passed the half-million mark in total passengers carried. Recent operation of the vehicles has been at an availability rate of 94 percent, reflecting steady improvement since initial startup.

The Morgantown system, which was conceived as a demonstration project and a site for development of new technology, cost about $64 million. Because costs exceeded the preliminary estimates (made without benefit of engineering), the system and it's sponsors (UMTA and the University) have had to endure a great deal of criticism. Although some of the criticism is no doubt deserved, the difficulties of the Morgantown system are now largely resolved, and should not be regarded as fundamental problems with this class of transit technology. Nearly all new transit systems in the last 10 years have encountered technical problems and cost overruns.

Ford Motor Company. The Ford Motor Company displayed an AGT system in TRANSPO in 1972, using a 24 passenger rubber-tired vehicle with an onboard switch. Based on this development, Ford has built two simple shuttle systems--one near Hartford and one in Dearborn, Michigan.

At Bradley International Airport, Hartford, Ford has installed a two vehicle bypass shuttle type of system, where the center of the line contains a 700-foot bypass section, the ends being single land track. The total length is 3700 feet, connecting the air terminal with a hotel and remote parking, and there are three stations. Speed is 30 mph; vehicles carry 24 passengers with six seated and 18 standees. Each vehicle can make 11 round trips in an hour, and the system capacity is about 550 passengers per hour in each direction. The system has a reported cost of $4.5 million, with operating costs estimated at $250,000 annually.

A similar system has been installed at the Fairland Town Center, a "new town" development near Dearborn, Michigan. Again, a bypass shuttle, the Fairlane system uses an 800-foot bypass in the center, has an end-to-end length of 2600 feet, and has two stations. It connects the new Hyatt Regency Hotel and the Shopping Center in Fairlane. Vehicles are slightly different from Bradley in using 10 seated and 14 standees, although the body shell is the same. The capacity is about 860 passengers per hour per direction, illustrating an inherent shuttle characteristic of higher capacities on shorter systems (as compared with the Bradley installation).

Although both Ford systems are simple in concept, the onboard switching and off-line station capability mean that the technology could readily be used on multiple station systems, and headways could be shortened according to the control technology adopted.

Ford has recently discontinued it's work in transit technology of this type, but the system is typical of several being developed in Europe and Japan.

Otis. Otis Elevator Company is the only U. S. manufacturer to take a distinctively different approach to technology, having developed a vehicle using efficient air cushion pads in lieu of wheels, and the linear induction motor for propulsion and normal braking. This unique combination of technologies permits a vehicle to be "docked," or parked by lateral movement in stations. Further details of the Otis system and a public system now being constructed at Duke University are provided in the next chapter.

AGT-II Systems

Description

The second type of AGT system differs from those in the preceding section in that the vehicles are designed primarily for operation in trains, and so are seen as simply small scale mass transit systems. Since switching is in the track instead of onboard the vehicle, headways are more likely to be 60 seconds or more. Capacity expansion would be accomplished by adding more cars to the train, as opposed to the possibility of shortening headways as with the AGT-I type system described. Speeds, capacities, and vehicle and guideway cross sections are all usually smaller than conventional forms of rail rapid transit or LRT, the objective being to devise systems with lower costs commensurate with lower demands typically encountered in urban areas, airports, or parks.

Status of Development and Applications

The principal U. S. manufacturers of these kinds of AGT systems, and the number of installations for each are listed below:

Rohr Industries, California	2
Vought Corporation (formally LTV)	1
Westinghouse Electric Company	4

Rohr Monotrain. Rohr purchased the Monorail division of WABCO in 1972 and has produced two small automated systems, one at Houston International Airport and the other at Pearl Ridge, Hawaii. The Houston system connects a hotel, parking, and terminals in the airport complex over a distance of about 3000 feet, with 6200 feet of track and 8 stations. Vehicles carry 12 passengers, 50 percent seated; operation is in trains of three vehicles at maximum speeds of 8 mph. Minimum headway is about three minutes, yielding capacities of about 720 passengers per hour in one direction. Almost no data on operation of this system were available for this report.

The Pearl Ridge installation now being built in Hawaii is a 304 meter (1000 feet) long shuttle connecting two shopping centers. The line has a single guideway and two stations; it uses one train of four vehicles, each carrying 12 passengers. Capacity will be 1200 to 1500 passengers per hour in each direction. The equipment is similar to that at Houston International Airport. Costs are said to be $1.1 million.

Vought Corporation. The largest innovative transit system installation in the United States, referred to as Airtrans, was built at the Dallas-Fort Worth International Airport by LTV Aerospace (now Vought Corporation). Design started in 1971, with the first passenger service in January, 1974. The Airtrans network has approximately 21 km (13 miles) of single track guideway and 51 stations; about 70 percent of the guideway is on-grade, the remainder in aerial structures. The system uses 51 rubber-tired passenger vehicles which operate at 27 km/hr (17 mph) at a minimum headway of 18 seconds. The vehicles handle 16 seated and 25 standing, and are normally run in a two-car train. Space has been reserved at stations to ultimately berth three-car trains. A quasi-synchronous fixed block system is used for fully automatic control. The total line capacity is about 16,000 passengers per hour.

Most of the start-up problems of the Airtrans system, principally reliability, appear to have been cleared up, and the operation is now achieving a high availability.

Westinghouse. Four automated guideway transit systems have been built for revenue service by Westinghouse Electric Corporation in the past 10 years. These systems are based on an experimental facility at Southpark, Pittsburgh, and all use the same basic technology: rubber tires for support and central rail guidance; automatic control; intermediate size vehicles; aerial guideways; and train operation at headways down to about 70 seconds.

The four Westinghouse systems are found at Tampa and Miami Airports, Busch Gardens, Williamsburg, and at the Seattle-Tacoma International Airport. Additional details on the Westinghouse equipment are provided in the next chapter.

Japanese AGT-II Systems. Quite a number of Japanese industrial firms have undertaken to develop rubber-tired equipment comparable to that of the U. S. manufacturers. See table on the following page.

Application of these Japanese AGT systems has been studied for the Toso new town in Chiba Prefecture and for Kobe and Osaka. They are basically intended to be used in a feeder-connector function and to serve existing rail lines in Kobe and Osaka, whereas in the new town application they would become the principal form of fixed right-of-way transit for the community.

European AGT-II Systems. Other equipment in this class has been developed and systems are being installed in European cities. These include the cable propelled POMA 2000, developed by Pomagalski and Cruesot Loire, and now being planned for Grenoble, France; and the VAL system developed by Engins MATRA, and now in a demonstration status in Lille, France. The Nancy project, which would have used an Otis/TTD system, appears to have been postponed indefinitely.

PERSONAL RAPID TRANSIT SYSTEMS

Description

A personal rapid transit system (PRT) consists of small vehicles, 2 to 12 passenger seats, operating under fully automatic control

JAPANESE AGT SYSTEMS

Name of System	Kawasaki	Mitsubishi	Toshiba	Hitachi	Mitsui
		Manufacturers			
Vehicle	KCV	MAT	Mini-Monorail	Para-tran	VONA
Length, ft.	30.0	21.0	14.8	24.6	17.4
Width, ft.	7.9	7.2	6.6	7.2	6.8
Height, ft.	10.3	9.5	7.9	10.3	10.0
Weight, lb.	18,700	10,000	7,600	12,000	9,000
Support	Rubber tires	Rubber tires	Rubber tires	Rubber tires	Rubber tires
Seats	24	10	8	22	--
Standees	26	22	23	18	--
Total	50	32	31	40	30
Guideway					
Switch type	in-track	in-track	in-track	in-track	in-track
Switch time, sec.	3	6	8	4	5
Guidance	side rail	center-rail	center-beam	center rail	center rail
Control					
Type	block	block	block	block	block
Headway, sec.	75	90	120	90	90
Speed, mph	36	36	36	36	36
Capacity					
Pass./hr.*	14,400	20,000	12,000	19,000	19,000
Train size	6	1-10	2-12	- -	3-12
Station					
Type	on-or off-line	on-or off-line	on-line	on-line	on-line

* With crush loading

on a network of guideways with off-line stations. Vehicles can be operated at headways of three seconds or less. Such a system is designed to provide immediate and direct transportation service from origin to destination without intermediate stops for an individual or a small group with common origin and destination. A vehicle control system dispatches vehicles to stations in response to actual or anticipated demand and provides control of the vehicle paths through the system network to minimize trip time. PRT may be operated in both demand-actuated and scheduled modes.

Status of Development

Personal rapid transit is not yet a fully tested and proven transit mode. Several types of vehicles with varying features have been developed; others are still in design and testing stages. Several possible modes of system control have been suggested, but not fully tested. The reliability, safety, and applicability of this system-type require further demonstration.

To date, no systems which can be classified as PRT are in revenue service or under construction in the United States. The current UMTA funded studies on the technology of such systems by firms such as Otis Elevator Company and the Boeing Company, referred to as High Performance PRT, address a concept as defined above, however current UMTA objectives are only to achieve a three second headway. Higher capacity would be obtained by using a 12 passenger vehicle and ride sharing.

The most advanced work in the PRT field is found in Western Europe and Japan. In West Germany a consortium comprising DEmag and Messerschmitt Bolkow Blohm (MBB) with the support of the Federal Ministry of Research and Technology has developed a PRT system called "Cabinetaxi." This system uses a three passenger capsule, and there is no provision for standees.

The Cabinetaxi project began with design studies in 1970, with federal support commencing in 1972. By October 1974 the initial 300 meter track (984 feet) was extended to 1136 meters (3726 feet) of track in a loop configuration with five vehicles. Tests at one second headways at 36 km/hr (22 mph) were carried out in 1974. Current plans include expansion of the track to 1.9 km (3.04 miles), three off-line stations and 24 vehicles, and testing of a 12 passenger capsule. Testing is to continue through 1977, with hopes that a small revenue system can be installed in 1979 or 1980. The Cabinetaxi has the following technical characteristics:

Guideway........Box girder for both bottom supported and top supported cabs

Support.........Rubber tires

Stations.........All off-line with spacings from .3 km to .8 km (.48 miles to 1.28 miles), capable of handling up to 1000 vehicles per hour

Propulsion.......Linear induction motor

Speed............36 km/hr (22 mph)

Headway..........0.5 to 1.0 seconds

Capacity.........15,000 to 21,600 seats/hour

Control..........Asynchronous operation

The Cabinetaxi is considered sufficiently mature by the federal sponsors that it has been studied extensively for Hagen, West Germany, and for Perlach, Freiburg, Leigenhain, Hamburg, and Marl. Through 1975, it is estimated that about 37.3 million DM ($13.3 million) have been invested in this development by the Ministry of Research and Technology.

In France, development of a PRT system called "Aramis" was started in 1970. A one-kilometer (3326 feet) test track was completed in 1974 near Orly Airport; three rubber-tired test vehicles seating four passengers were built. Initial tests have been completed by the manufacturer, MATRA; the second phase is under the management of the Regie Autonome de Transports Parisiens (RATP), the regional transportation authority for Paris. RATP is reported to be funding a 30-month program, which started in 1974, costing about $8.3 million. This would involve a three-kilometer line with three stations, and about 10 to 15 vehicles.

The unique technological feature of Aramis is the concept of "platooning," where vehicles operate in electronically coupled "trains," i.e., vehicles would comprise a paltoon. The platoons would operate at about 60-second headways, so the effective headway for 30 vehicles would be two seconds.

Aramis is being studied for Val de Marne, Nice, and other areas in the suburbs of Paris.

The most advanced PRT development may well be in Japan, where the CVS (computer-controlled vehicle system) is being developed by a consortium of Japanese industrial groups, the Ministry of International Trade and Industry, and the University of Tokyo. The CVS test facility involves 4.8 km (3 miles) of track and 60 vehicles, of which part are passenger and others are for freight. The passenger vehicles have four seats with no standees allowed. All vehicles are rubber-tired and operate on concrete running surfaces.

Control of the CVS is through a synchronous moving block system with a three-level computer. One controls the high-speed operation, a second the low-speed inner ring, and a third supervises the overall operation and monitors the first two computers. Early this year, it was reported that tests had been successfully conducted at 0.9 seconds headway at Higashi Murayama, and that these were run at 60 km/hr (37.5 mph). The data transmission rate was 1200 bits/second; the developers feel that with a higher data transmission rate, 0.7 seconds headway is technically feasible with the current equipment. These tests were run on the 2 km straight section of track. There were three vehicles used, which started at two seconds headway for 150 meters, then closed to 0.9 seconds headway for 250 meters, then returned to the two seconds headway.

Testing at the facility is scheduled to continue for several years, of which a Phase I effort is scheduled to be finished in 1977. Phase II will involve tests on the entire fleet under computer control.

Examples of Application

The concept of personal rapid transit is relatively new. Only a very limited number of personal rapid transit systems such as those described have reached the test phase of development and none has yet been demonstrated on a large scale or implemented in actual service in an urban region.

Performance Characteristics

Since no examples of personal rapid transit in practical service yet exist, performance characteristics for actual system operation are not yet available. The major physical and performance characteristics of recent demonstration systems are described in the section on Status and Development. These characteristics may vary depending on network size, vehicle types, and area of application, and are therefore subject to significant potential variations. Generally, systems of this type would have a top speed of approximately 40 mph, depending upon grade, and seated capacity between 7,200 to 21,600 passengers per hour.

Cost Characteristics

No regional PRT system has been constructed anywhere and none have been brought beyond the conceptual testing stage. There is, therefore, no actual experience on which to base a reliable estimate of cost. Smaller installations constructed for demonstration purposes have cost from $5 to $20 million per mile, but it is hazardous to apply these costs to a large system because of the hidden development costs and the emerging state of the technology.

A 100-mile PRT system was proposed for the Denver region at an estimated average cost of $10 million per mile, including vehicles. This system involved mostly aerial construction with only two miles of subway. Studies for San Diego indicated that costs per mile might be expected to be equal to, or greater than, a heavy rail rapid transit system. Only after much further development and testing of PRT can a dependable cost estimate be made.

CABLE SYSTEMS

Description

Within the category of Cable Systems, distinction is made between the following types of cable supported or propelled systems:

- Trams. Classical trams use large cabins carrying up to 100 or 125 people (standing) in which the weight of the cabin is carried on support cables, and the "haul" cable attached to the cabin provides propulsion. The trams are operated as synchronized pairs such that there are two cabins on each line; the upper cabin departs when the lower one does, and the cabins pass each other at midpoint. The trams are inherently point-to-point systems and do not lend themselves to multiple station applications.

- Cableway. If the cable is fixed and provides only support for the vehicle, then onboard propulsion motors can be used to draw the vehicle along the cable. This is the case with the "Aerobus" system developed in Switzerland.

- Gondolas. These are of two types. In one case, the cable provides both support and propulsion, so the cabin is latched on and off of a moving cable. In the second case, there is a support cable which does not move, and a haul cable for propulsion.

- Cable Car. The classical cable car is exemplified by those in San Francisco, where the cars are supported by steel tracks in the street. A cable moving at constant speed of 9 mph provides propulsion; manual means of attaching the car on and off the cables are used. A modern version of this is found in the "POMA 2000" system, where rubber tires support a vehicle running on a guideway, and automatic coupling and uncoupling to the cable is used. Thus, no onboard operators are required.

Status of Development

Trams and gondolas are fully developed as technologies, with scores of installations around the world.

A cable way system has been under development by GMD Engineering in Switzerland, and it is referred to as "Aerobus." This uses a 66 foot long articulated vehicle weighing 15 tons supported by a cable.

In the Aerobus system, a cable running bogie is used to support the vehicles from the top and for power collection; the cable in turn is supported by a catenary which gives it a compensated upward curvature so that as the vehicle passes through, the ride is level. Wherever turns of less than 1000 foot radius are required, and for station segments, the vehicle bogie runs onto an "I" beam for support. The fixed cable supporting the vehicle is carried on tall cable-guyed pylons which may be up to 3000 feet apart (typical spacing is 700 feet). Vehicles are electrically propelled and have a reported speed of 50 mph, depending upon grade.

The POMA 2000 is being developed by Pomagalski SA in Grenoble and Creusot Loire Enterprises, Paris, with sponsorship by the French government and the City of Grenoble. In the POMA 2000, a passive rubber-tired vehicle is used with cable propulsion, so it can be visualized as a modern cable car. However, the vehicle is automatically latched on and off the cable, which has a speed of 20 mph.

A prototype vehicle of the system was built in 1971; two additional prototype vehicles were built in 1972, with an 1800 foot test track in Grenoble. The passive vehicle yields a quiet, high quality ride, and reliability is reported to be high. The system is fully automated. Vehicles carry up to 40 passengers, with seating/standing ratios ranging from 8/32 to 16/24.

Examples of Applications

Trams and gondolas are found in numerous ski resorts and other recreational areas.

A two-mile long installation of double-track line of the Aerobus has been made in Mannheim, West Germany, and is operational. It is reported to have cost $3.3 million and to have a line capacity of 5000 passengers per hour in one direction.

The POMA development continues. Four sites for implementation are being considered, three in the Paris region, and one in Grenoble. A presentation to a committee of the Ministry of Transport was made in July, 1976, and a site selection is hoped for in September. Expectations are that a revenue segment will be operating in 1977.

Performance

The cable speeds on trams and gondolas are limited by the American National Standards Institute (ANSI) to 1000 to 1200 feet per minute, depending on applications. This is on the order of less than 15 mph. The line capacity of gondolas is set by the rate at which the cabins can be injected into the line, generally a minimum of 18 to 20 seconds apart. This results in capacities of about 1200 per hour for six passenger cabin gondola systems.

The Aerobus is an attempt to gain the advantages of the lower costs of cable supported systems without incurring performance limitations. Some relevant performance characteristics of the Aerobus system are listed below:

Line Speed	60 mph+
Grade, maximal	12%
Minimal radius	100 ft. (using I-beam simulation) 1000 ft. (on cableway)
Maximal span between pylons	3500 ft.
Average span length	750 ft.
Vehicle capacity	60 seated, 40 standing (large vehicle) 20 seated ("mini" vehicle)

The POMA 2000 is an attempt to raise the performance of cable propulsion systems by using an alternative support technique. Thus, an aerial guideway is almost mandatory for most applications. The physical characteristics and performance of the POMA 2000 are tabulated below:

Line Speed	20.6 mph (33 km/hr)
Average speed	12.5 to 15.6 mph (20-25 km/hr)
Grade, maximal	15%
Minimal radius	32.8 ft. (10 meters)
Loading time	10 seconds
Headway	32 seconds
Maximal vehicle capacity	8 seated, 12 standing
Nominal capacity	33
Nominal seating	16
Line capacity	6000/hr (nominal) 9000/hr (maximal)
Vehicle Height	8.2 ft. (2.5 meters)
Vehicle Width	7.2 ft. (2.2 meters)
Vehicle Length	14.8 ft. (4.5 meters)

Cost Characteristics

The special purpose characteristics of the tram and gondola installations preclude useful generalization about costs. Gondola installations should range from $1 million to $1.5 million per mile, based on ski resort experience.

A new serial tram, built by a Swiss firm, now links Roosevelt Island in the East River with Manhattan over a distance of 3,134 feet. There are two cars on the line, each capable of handling 100 passengers; top speeds are 16.3 mph, and the trip is made from Manhattan to Roosevelt Island in 3.5 minutes.

Capacity is said to be 1500 passengers per hour, one way. The costs were $6.8 million, or roughly $11.42 million per mile. Operation of the system is stopped if wind gusts reach 45 mph.

The costs of the POMA system were not available, but will be approximately those of the AGT systems.

The Aerobus system is expected to cost in the range of $2.5 million per two-way mile, including stations, vehicles, and electrification and communications systems, but excluding land acquisition.

COG RAILWAY SYSTEMS

Description

Cog-assisted railways are relatively common in mountainous areas where conventional railroads are unable to safely ascend or descend steep grades. While conventional locomotives normally negotiate only modest grades (no more than 5%-10%), the maximum workable grade with a cog railroad can be increased to almost 50 percent, with installations commonly used on 25 percent grades.

Cog railway systems normally fall into one of two principal operational categories. In one type of system, two cogged wheels under the locomotive run up to a steel ladder laid between the rails. In the other type of system, the steel ladder is replaced by two racks laid close together with the "tooth" of one opposite the "jaw" of the other.

Status of Development and Applications

Cog railroads have been in use for over 100 years, both in the United States and in Europe. The first cog railway in America was the Mt. Washington Cog Railway in New Hampshire, which still operates using vintage equipment. The Swiss Alps are host to numerous cog-assisted rail systems, including the well-known Rigi Railroad and the Brunig Line of the Swiss Federal Railway. This type of rail technology is well-proven and has been successfully employed in many parts of the world for many years.

Cost and Performance Characteristics

Alan M. Voorhees & Associates, in a study for Snowbird Corporation in 1973, evaluated the feasibility of installing a cog-assisted railroad in Little Cottonwood Canyon. The cost and performance characteristics which were developed in the AMV study are used in this report. The system would be based on a mix of long stretches of conventional grade track and short stretches at 20 percent grade, which would utilize cog-assisted equipment.

Cost for the 7.4 mile system in Little Cottonwood Canyon was estimated at $31.5 million (1973 dollars), and capacity was estimated to be 2000 persons (one direction) per hour.

RECOMMENDATIONS FOR

LONG-RANGE TRANSPORTATION SYSTEM DEVELOPMENT

Evaluation of Transportation Alternatives

This long-range portion of the Wasatch Canyons Transportation Study is designed to be a conceptual guide to future options for transportation system development in the Wasatch Canyons. As such, recommendations are made based on the relative applicability of the three basic transportation system alternatives defined earlier with respect to the three prototypical Canyon growth scenarios. This relationship between transportation systems and growth scenarios is illustrated below.

Canyon Growth Scenarios	TRANSPORTATION SYSTEM DEVELOPMENT ALTERNATIVES						
			Fixed Guideway Systems				
	Buses - Mixed Traffic	Buses - Reserved Busway	Monorail	Automated Guideway Transit	PRT	Cable Systems	Cog Railway
(1) Low or Moderate Growth	X	X					
(2) Significant New Development		X	X	X	X	X	X
(3) Major Expansion of Multi-Area Resort Development						X	X

This table indicates the conditions under which different types of transit systems would appear to have the greatest utility. Under Canyon growth/development Scenario 1, defined to be a growth rate equal to or less than currently projected for Little Cottonwood Canyon by Snowbird and the Utah Ski Association, it would seem inappropriate to consider the need for any type of fixed guideway system. The bus system currently in operation can provide the necessary capacity at peak periods, and, in addition, automobile restrictions and/or remote parking in connection with a transfer facility located in Salt Lake Valley can be employed to alleviate growing congestion or up-Canyon parking problems. The construction of a new exclusive busway would also appear to be unnecessary, but automobile disincentive/transit incentive policies could have the effect of drastically limiting private auto use of existing Canyon roads, especially at peak use periods, and reserving such excess capacity for mass transit.

The second growth/development scenario, which envisions growth and recreational use increases holding at about 10 percent per year beyond a five-year horizon, implies recreational demands which could warrant the installation of a capital-intensive system. While the means of financing such a system has a number of inherent options, it is beyond the scope of this conceptual guide to explicitly explore such options. It is clear, however, that the growth and recreational use of Little Cottonwood Canyon implied by this scenario would create traffic demands beyond the reasonable capacity of the road at average peak times, and would certainly imply a parking deficit at the resort areas. Efficient management of automobiles through use of a transit transfer center (as outlined in the Short-Range Plan) with certain auto disincentive programs would be required, as a minimum measure, to accommodate resulting demands for Canyon use. Of course, policy decisions could result in the development of a fixed guideway system which would probably negate the requirement for automobile restrictions (unless such a fixed guideway system were built using at-grade sections on existing roadbeds). Since this scenario does not envision the connection of the resort areas, any of the fixed systems reviewed earlier would appear to be workable.

The third growth scenario encompasses various concepts which have been in circulation for some time regarding the eventual link-up of the major resorts in the Wasatch Front through over-mountain transport schemes. The levels of development and activity generated by such a "Zermatt" scheme would likely imply the necessity of a well-conceived and complete-coverage mass transit system. Probably the only realistic systems which could embody the necessary performance attributes would be an aerial cable system or a network of cog-assisted alpine railway links. It is assumed that since this development concept would be totally dependent upon a mass transit scheme, access into the resort region could be accomplished cost-effectively by extensions of the systems to the gateway locations.

Recommendations for Future Transportation Systems and Services

Overwhelming evidence would appear to indicate that even in the long-range future, some combination of bus transit, remote parking, and auto-restrictive policies would be sufficient to insure safe and reliable Canyon transportation, within the bounds dictated by peak use demands. However, this does not, of course, preclude the possibility of installing a fixed guideway system, particularly in Little Cottonwood Canyon, for the purposes of environmental protection (especially water-related pollution), safety, or other factors.

Review of the various fixed guideway mass transit systems described earlier in this report suggests that, given the unique characteristics of Little Cottonwood Canyon, a cableway (or aerial tramway) system presents the most desirable option should the decision be made to construct a high-capacity, fixed transit system. Significant factors which lead to this recommendation include the following:

- An aerial cableway system generally avoids the problems associated with snow removal and avalanche protection.

- The existing highway could still be used since no at-grade guideway construction would be required.

- Little new right-of-way would be needed--only that required for placing support pylons.

- Views and scenic vistas would be unparalleled from an aerial system.

- While the ultimate high-end capacity of an aerial cableway system might be less than other mass transit systems, its capacity is certainly adequate for application in the Canyon setting.

- Noise and emissions are less with this type of system than with other applicable systems. Also, an aerial cable system has a negligible impact on the ground surface as compared to a railroad or other at-grade or ground-supported systems.

- Although no full systems using cableway technology (stationary cableway with self-propelled vehicles and on-line electrical pick-up) have been built in the U. S., estimated capital costs seem to compare very favorably with other transit system options for the Wasatch Canyons.

Based on the above factors, contact was established with Aerobus Development, Ltd., and its U. S. manufacturer/supplier, Aerobus of North America. The Aerobus system appears to be the leader in cableway technology, having developed systems in Europe and presently designing several applications in North America. Aerobus engineers were asked by PBQ&D to study the Little Cottonwood Canyon setting and develop a generalized cost estimate of a cableway installation between the Canyon mouth and the Town of Alta. The Aerobus cost estimates are as follows:

Seven miles of Aerobus guideway (two-way)	$14,000,000
Three stations (Base, Snowbird, Alta) @$100,000	300,000
Six Aerobus vehicles (US mfg) @$300,000	1,800,000
One service/inspection tug	100,000
Three switch terminals @$200,000	600,000
Seven power/line boosters @$50,000	350,000
One service center (car barn) 100ft.x 100ft.	1,000,000
Signal/communications equipment	200,000
Spares & inspection/test equipment	150,000
Transport/check-out/insurance coverage	150,000
TOTAL	$18,650,000

While PBQ&D cannot verify the accuracy of these line item cost figures, it is felt that the total is realistic with respect to the known costs of more well-established transit hardware. The $18.65 million figure is apparently all-inclusive with the exception of land acquisition costs for stations and support structures.

Summary

The purpose of this report has been to develop a recommendation on long-range transportation services for the Wasatch Canyons. In view of all of the information presently available regarding future Canyon land uses, recreational development, and resort area activity, it does not appear that a fixed guideway or other capital-intensive transit system will be warranted. Instead, it would appear that a well-scheduled, well-marketed bus transit system utilizing a remote parking/transit transfer facility with certain auto-restrictive policies should suffice. However, should the decision be made by the resort operators and/or the public that a high capacity, environmentally sound fixed guideway system is desirable, it is recommended that the Aerobus or similar cableway system be considered as the most appropriate for the Canyon setting. Only if some or all of the following events occur should such a system be given serious consideration:

- Increased summertime and other non-winter activities are emphasized in the Canyons and the areas develop a more multi-seasonal pattern of intensive uses.
- The deterioration of water quality in the water supply systems and/or other environmental pollution in the Canyons exceeds tolerable thresholds for health and aesthetic well-being.
- The resort areas mutually develop an extensive approach to linking the recreation areas and jointly pursue the development of regional mass transit connections.
- The operational and maintenance costs of operating the bus system become so great over time as to render cost-effective the capital amortization of a less labor-intensive fixed guideway system.