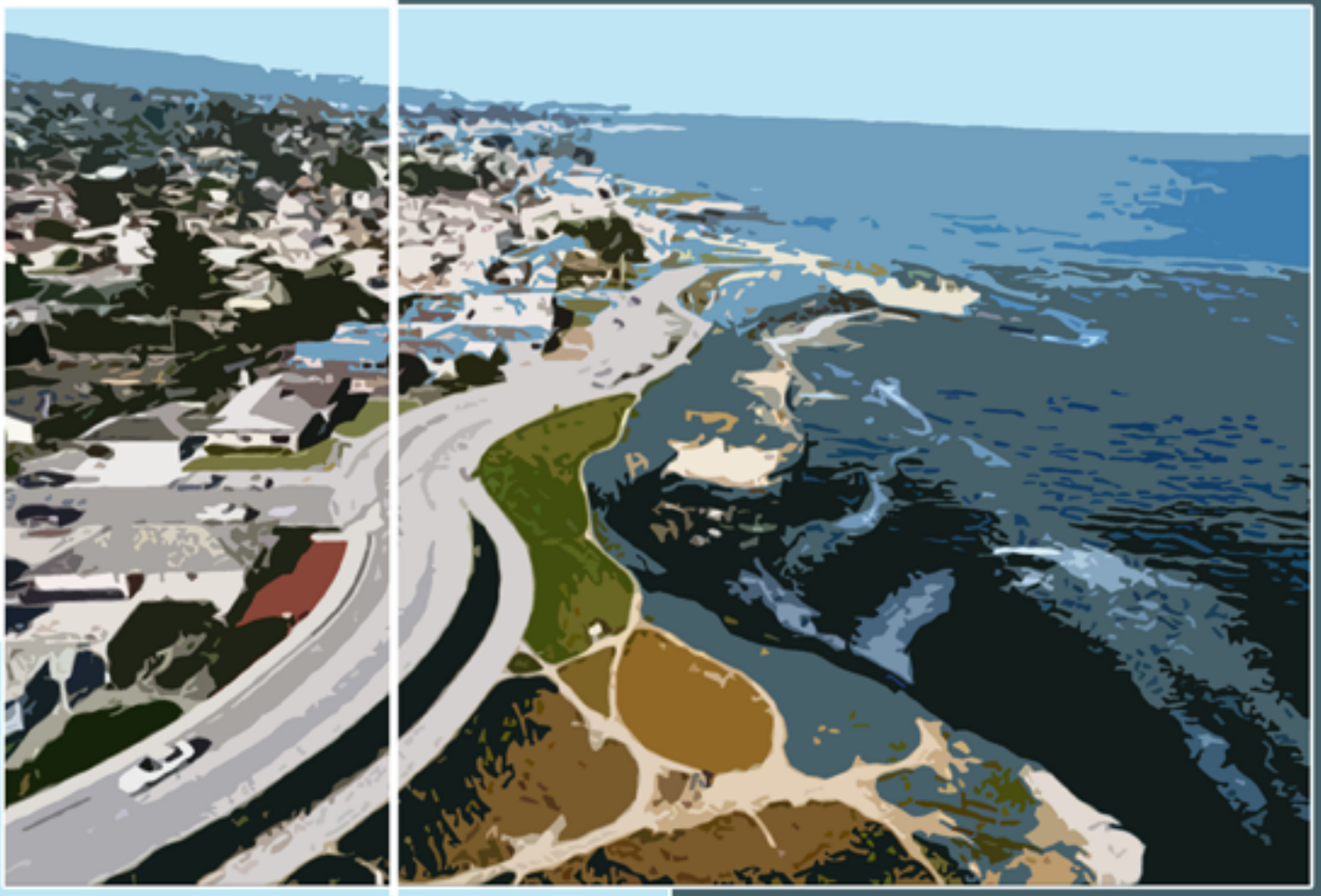

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Report on the Feasibility of Personal Rapid Transit in Santa Cruz, California

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Prepared by da Vinci Global Services
for the City of Santa Cruz, California

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Changes from draft:

A draft version of this report was released in November 2006. A few significant changes should be noted in this version.

1. The ULTra system was previously described as having a contract to deploy their system at Heathrow Airport in London. Since November, they have commenced construction of this project, the world's first modern PRT system. They report continued success at hitting their milestones. The system is expected to be first operational in 2008.

   The original ULTra test track remains operational and available for inspection by a delegation from Santa Cruz.

2. The Vectus system was described as having a projected completion date in 2007. That track has been completed, and operational testing of the Vectus PRT system has begun. With their focus currently on testing, it is not clear when visits from Santa Cruz can be scheduled.

3. In 2005, the State of New Jersey commissioned the international consulting firm Booz Allen Hamilton to study PRT for their state. The results have not been published, but a presentation to the Advanced Transit Association in January 2007 was enlightening. It described the state of the PRT industry as at the "inflection point," shifting from years of research to early systems before beginning a stage of rapid growth.

   This presentation also validated many of the claims – still estimates – of PRT costs and PRT's ability to attract riders from their cars.

   The presentation concluded with a discussion of several business models for implementing PRT, focusing on modeling PRT as a public utility.

1. Purpose of this Report

Santa Cruz, California, has long prided itself on its activist reputation. They think differently. People in Santa Cruz don't sit back and wait for others to solve problems, they step up and work for a solution.

A number of residents are working to improve the transportation system for the benefit of Santa Cruz, and so that Santa Cruz can serve as an example that can be emulated by others. These residents feel strongly that personal rapid transit (PRT) could enhance the existing transit system, and thereby reduce the use of automobiles.

Less automobile use would lead to improved traffic conditions, cleaner air, and reduced expansion of streets and highways in Santa Cruz. If travel times are improved, people will waste less time on the road and thereby enjoy a higher quality of life.

PRT is a much-discussed technology that is undergoing a period of intense technological development. At least four companies are undertaking well-funded development programs, and several others are attempting to follow them.

This report attempts to assess the state of personal rapid transit development today. It identifies some potential funding opportunities that Santa Cruz could pursue in order to build a personal rapid transit system. The report also identifies areas for caution as PRT is investigated further.

2. Current PRT Activities

As PRT developers have hit new milestones in recent years, interest among potential buyers has increased. Activities that have been publicly announced are listed below:

- In 2005, the New Jersey legislature assigned the consulting firm Booz Allen Hamilton in cooperation with Rutgers University to prepare a report on the viability of PRT in New Jersey. The report is not yet final, but a draft presentation indicated that PRT was likely to have lower construction and operating costs than other fixed-route options. PRT system capacity was sufficient, even for New Jersey's density.
- In Sweden, the EDICT program's study of the Kungens Kurva shopping area – an area with a large number of visitors – indicated that a PRT system would spur greater activity and allow 17% more travel in the area while also reducing automobile use so that road traffic actually dropped by 8%.
- In 1999, the ridership study of the Cincinnati Central Area Loop Study led by Parsons Brinckerhoff Ohio concluded that PRT ridership would be three to five times higher than any other alternative as a downtown circulator in Cincinnati.
- In Seattle, a Major Investment Study prepared by the firm BRW for the area around SeaTac Airport concluded a PRT system that connected to the airport and regional mass transit could reduce the overall surface traffic in the area by 9%. The study recommended further pursuit of PRT when the technology is available.

Among vendors:

- In 2002, Advanced Transport Systems Ltd (United Kingdom) completed a two vehicle test site for their ULTra system in Cardiff, Wales. In 2003, they completed passenger testing.
- In 2003, the Taxi 2000 Corporation (Minnesota) completed a prototype vehicle on a 60-foot test track. The company reports thousands of visitors have ridden the vehicle.
- In 2005, Vectus PRT (Korea) announced they would build a test and demonstration center in Sweden. This broke ground in 2006 and testing is currently underway.
- In 2006, it was announced that BAA would purchase an ULTra PRT system for London's Heathrow Airport. To date, they have passed all technical milestones.

3. Introduction to Personal Rapid Transit

Personal Rapid Transit (PRT) is a mass transit system offering the users a set of advantages unique in the transit world:

- No waiting (most of the time). Much of the day vehicles will be in stations waiting for passengers. During rush hour, waits are intended to be kept short, below five minutes according to some designers and below two minutes according to others.
- Express service, meaning your vehicle makes no other stops between leaving your origin and arriving at your destination.
- A network that serves where the passenger wants to go. Apart from taxis and possibly carpools, most transit systems run along a single path, requiring transfers to reach destinations not on the path. PRT systems are designed in a grid or as a series of connected loops, allowing passengers to select from among many stations within the service area and receive point-to-point service.

By having these features, PRT manages to address many of the concerns people have about riding transit: learning a system schedule, making connections and transfers that involve uncertain schedules, and dealing with a service that is slower than their automobile alternative.

For people who need to travel in the vicinity of a PRT network, studies have predicted a significant shift in mode share toward PRT if it were built. Studies also indicate that even for people whose path is not fully in vicinity of the PRT network, other access modes such as buses and carpools would see an increase in mode share as people use these choices to connect to PRT.

PRT designers are often motivated by a truism in transportation: Frequent service and fast travel times will attract riders. PRT developers have used this maxim to design their systems, and these are distinguished from other mass transit modes by four factors:

1. Automated Systems

PRT designers rely on automation to control the movements of the vehicles. Design practices of hardware and software development have advanced to the point that the safety rates on automated systems are far above those of human-operated vehicles.

Many monorails and some trains are already running with automated control systems. These more traditional alternatives send their vehicles down a dedicated track, and their path is fixed. Current automated transit systems function primarily as elevators, often stopping at every stop.

PRT designers typically take the automation to a level higher than most monorail or train systems, though, by not following pre-set paths. Instead, a vehicle will often take a series of turns as it finds the shortest path between two stations. Doing so requires a higher level of precision in switch timing and vehicle control than we see in monorail or train systems.

2. Small Vehicles

PRT designers have universally chosen small vehicles for their system. With automated systems designed to serve many point-to-point trips, large vehicles would almost never be able to fill up to serve these dedicated trips. Research in the 1970s showed that for the scenarios they considered, large vehicles would be inefficient for PRT systems.

Also, for designers of elevated systems, small vehicles allow the system to be built with minimal size and maximum cost efficiency. For example, train bridges have to be built to withstand a very heavy load when the train passes, but otherwise the bridge sits idle. PRT systems with small vehicles spread out this load, keeping the loads very low and allowing much smaller structures to be built.

Thus, designers have chosen vehicles that carry small parties. The exact size varies by vendor, with some systems holding only three adults and others holding up to six.

3. On-Demand Service

With small vehicles, it is necessary to run many more vehicles to achieve the same system capacity as with larger vehicles. This creates a big advantage for passengers.

Once a vehicle drops off a passenger, it can wait in the station for the next passenger. Or, the automated control system can recognize a need somewhere else, and it can automatically move the car to where it is needed most. This cuts passenger wait times and during most of the day can eliminate waits altogether. Outside of rush hour, it can achieve the goal of having a vehicle always waiting for you when you arrive at a station.

PRT vehicles make only one stop per trip, never stopping at other stations or for traffic lights or stop signs. This means that passengers get the fastest possible trip. This will often mean that a PRT trip is much faster than driving by car.

4. Separated rights-of-way.

To achieve the one-stop goal, PRT vehicles from most vendors travel along dedicated rights-of-way without interacting with pedestrians or automobiles. Some developers, such as ULTra, typically portray their systems at grade (in separated lanes) whenever possible, while other developers, such as Taxi 2000 and Vectus, plan on their systems typically being elevated.

A few systems, notably the Frog system mentioned in this report, do allow their vehicles to mix with some other traffic. This generally limits speeds, but it allows much greater flexibility in implementation.

The four characteristics listed above are not the only differences between PRT and other transit modes. PRT allows other changes in design, and in some cases it requires them. For instance, to achieve the desired capacities while maintaining a high level of safety, traditional track-based switches are ineffective, and designers have to develop switches that function on-board the

vehicle. The fact that vehicles don't stop at all the stations along a path eliminates the biggest disincentive to building additional stations, since adding more train stations typically slows down the rides for everyone already on the train. Hence, in a PRT system, it is okay to build many more stations than a train designer would. Consquently, this results in shorter walks and higher usage by passengers.

Ridership

In many respects, the debate over PRT boils down to a simple set of assumptions about ridership by proponents and critics.

To PRT critics, PRT would be unnecessary if we just put sufficient resources into bus and rail transit. Better, more frequent service is the answer to our transportation woes, they say.

PRT proponents, on the other hand, see evidence that Americans are addicted to the comfort and convenience of the automobile. Drivers will shift to hybrids or electric cars, but they will only quit driving when transit is fast and convenient. Because we no longer live and work in the hub-and-spoke configuration of the old days, bus and rail have difficulty serving the cross-town routes that most drivers are actually making. Therefore, an on-demand alternative that offers direct-to-destination service is the only hope for making a serious impact on Americans' auto-driving habits.

Evidence from a number of studies weighs on the side of the PRT advocates. Except when auto driving is severely discouraged either by congestion or the cost of parking, it is very difficult to convince drivers to shift to even high quality transit that is deemed "slow" in comparison to their car. However, on-demand systems that are easy to use and in convenient locations can attract high ridership, as evidenced by studies in Seattle, Cincinnati, Sweden, England and elsewhere.

4. Reasons for the Study

A. Promise of PRT

This study was motivated by grassroots activity by concerned citizens of Santa Cruz. Each has his or her own motivations, with some people being primarily impressed by the potential environmental impact of PRT and others by its potential social or economic benefits. Interviews with these activists revealed that almost all were concerned simultaneously about the future of Santa Cruz, the United States, and the world in general.

Fundamentally, these citizens were motivated by a number of potential positive impacts of PRT. Further, they were inspired that these benefits could come from a system that was relatively small, inexpensive and flexible.

Environmental Benefits

In interviews with Santa Cruz supporters of PRT, it was evident that the positive environmental benefits of PRT were a prime factor in their interest. Multiple Santa Cruz residents interviewed cited meeting the Kyoto protocol requirements as a significant concern that motivated them to consider PRT.

PRT's ecological gains are primarily driven by its ability to attract additional riders to transit and the fact that it is projected to use less energy per passenger mile than other forms of transit. In combination with the existing Santa Cruz Metro bus system, PRT is a mode that can meet the needs of traditional car drivers.

By attracting higher ridership, PRT replaces an automobile trip with a trip of much higher efficiency. The efficiency gains come from running vehicles with electric power in a non-stop manner, eliminating the gasoline engine and the power wasted with starts and stops. The result is decreased emissions of unburned hydrocarbons, nitrogen oxides (NOx), carbon monoxide (CO) and carbon dioxide (CO_2).

Further, a PRT system would allow more and more trips to made along existing corridors without having to expand streets and highways. This saves real estate, and sometimes results in saving precious habitats, trees and wetlands.

Economic Benefits

Some advocates point to what has long been known in manufacturing: it is costly to waste valuable resources. In an era when components are regularly shipped via overnight services to be ready for the factory floor the next day, we allow our most productive resource – our human capital – to sit idle on crowded freeways and streets.

Smoother transportation results in more productive hours for workers. These hours can be spent at home, at work, or at play. No matter how they are spent, they are more valuable than sitting in traffic. There is also the potential for PRT travel time to be productive, since the vehicles are fully automated.

The largest single component of the Santa Cruz economy is tourism. Smoother traffic increases the attractiveness of Santa Cruz as a vacation destination, while worsening traffic would certainly have a negative impact. Therefore, if PRT can be used to relieve the traffic pressures during peak leisure times, this could result in a boost to the local economy. Similarly, by more easily connecting these beach visitors to the shopping and dining destinations downtown, the Santa Cruz economy would receive a positive impact even if the number of visitors stayed the same. The PRT system itself could possibly be something of a tourist attraction itself.

Significantly, to the extent that PRT is less costly than other transportation alternatives, it can be a savings to the local, state and national budgets. This comparison depends on the cost of the PRT system and on the cost of the alternatives, but there is no question that in some situations an elevated PRT solution could be less costly than additional highway lanes at grade.

Finally, some advocates identified potential gain to Santa Cruz from being involved early in a product's development. They cite additional manufacturing jobs that could be created near a

PRT company's demonstration site. This report does not conclude that manufacturing jobs are likely to materialize. Santa Cruz County is one of the most expensive counties in California, a high cost state, so it is unlikely to be the site of much new manufacturing. However, a company's demonstration site is likely to spawn certain technical, research and development, and training jobs.

Social Benefits

The final category of benefits would include various social benefits that people have identified from the adoption of a personal rapid transit system. These include benefits associated with other forms of transit.

First is safety. The statistic of 46,000 road deaths per year was cited by one Santa Cruz PRT advocate as a compelling reason why a safe transportation system was important to him. (Note: Data from the Bureau of Transportation Statistics indicates there were 42,643 road deaths in 2003.) The Morgantown PRT system has completed over 110 million significant injury-free passenger miles.

Second is the higher level of social interaction associated with transit ridership. While PRT riders do not have long waits and do not all sit together on a vehicle with a single set of stops, there is still considerable more interaction than when 97% of the people are all driving to work.

Third are the indirect effects of increased transit use, which includes global benefits from the reduced use of carbon fuels and carbon emissions. This is linked to positive macro-political considerations. This sentiment is particularly strong among those who oppose the war in Iraq. It surfaced repeatedly in interviews among both PRT supporters and non-supporters.

Civic Benefits

Obviously, better living through better traffic conditions topped people's concerns when asked about the benefits of PRT in Santa Cruz. On the present course, traffic will only get worse in coming years, and PRT was seen as one of the few options that could reverse this trend.

Secondly, across the board, the underlying element behind people's support for PRT was their belief that Santa Cruz could be a world leader.

Santa Cruz has a reputation for taking a stand on important matters, and many people believe this is an area worth taking a stand on. They believe that a minimal investment in time and energy, if used to create a first PRT demonstration site in the U.S., can serve as a positive example to communities worldwide. It is a point of civic pride that Santa Cruz is willing to take a stand on important issues, and playing host to a world-changing technology would certainly bolster that reputation.

Further benefits were seen from possibly repairing the relationship between the university and the city. Continued expansion of the university will increase the number of students, faculty and staff making trips daily, putting ever-increasing pressure on the streets around the campus. PRT was seen by some as an area where the city and university could cooperate to the benefit of both parties.

5. Technologies

To this point, we have discussed PRT in the abstract sense. In reality, there are different PRT systems under development. Unlike buses or trains from different manufacturers, PRT systems are not equivalent and interchangeable. Instead, each brings its own set of strengths and benefits and its own set of weaknesses and costs.

Below we will review the major PRT systems that exist or may be available to Santa Cruz in the near future. Information is current as of March 2007, and all opinions stated are the subjective conclusions of the authors, except where noted.

A review of systems found:

1 historical system, characterized by a successful track record of near-PRT operation,
4 companies with development programs in advanced stages, and
3 early stage companies who may be interested in deployment in Santa Cruz.

The four companies marked "advanced" have development programs underway with outside funding. The ULTra system is currently being built at London's Heathrow Airport. A demonstration and test facility for Vectus is being built in Sweden. Taxi 2000 has an indoor prototype in Minnesota. Frog's PRT system is still under development, but they have larger automated vehicles in service around the world. Each of these companies has reached a stage where they could realistically tackle a project in Santa Cruz.

The early stage companies have little (or at least undisclosed) funding, and are currently trying to pitch their ideas to customer and financiers.

For any of these companies, Santa Cruz should set a high standard, requiring companies to demonstrate they have A) financing and B) partners ready for design and manufacturing of the system and all of its components.

A. Historical - Morgantown

We begin by mentioning the PRT system that exists on the campus of West Virginia University. An automated transit system that was completed in 1976, it operates during the evening in "group" mode, making regular scheduled stops at five stations on the route. During the day, it operates in "PRT" mode, where each vehicle makes a non-stop trip between two stations.

The Morgantown system is very different from today's proposed PRT systems. For one thing, even in PRT mode, it still moves passengers in groups, with up to 12 students seated and up to 8 additional standing passengers. Does the Morgantown system hold any lessons for Santa Cruz?

Our conclusion is yes, especially if you consider the distinction between technology available today versus what was available at the time. Shown below are a computer and a mobile phone from 1973, followed by their equivalents today. Technological progress has made the modern device sleeker, smaller, quieter, more efficient and much cheaper.

Computers, 1973

Computers, Today

Mobile Phones, 1973

Mobile Phones, Today

PRT, 1973

PRT, Today

Clearly, design and style have improved greatly from this period. Morgantown proves the important point that the basic methodology of point-to-point operation is feasible. The Morgantown PRT system also demonstrated vehicle-based switching, a “moving slot” control system and 15-second headways.

The Morgantown project also proves the usefulness of automated transit in a place like Santa Cruz. Morgantown has 30,000 residents, and the university has 19,000 students. Like Santa Cruz, the largest part of the university campus is at the top of a hill above the city. There is also a portion of the West Virginia University campus in the city at the bottom of the hill. Commuting between the two was difficult and time consuming for the short distance involved (just 1.5 miles as the crow flies, but 50% longer by the main city streets). The city and university both felt there must be an easier way.

Morgantown’s PRT solution is now an integral part of the operation of West Virginia University. The system carries an average of 15,000 people per day, and achieved a new record of 31,280 set earlier this year on the first day of fall classes.

Over the last 29 years, the system has moved over 63 million riders, with no injuries requiring even as much as a trip to the emergency room.

The system used in Morgantown was extremely costly, and its development was complicated by political factors related to the 1972 presidential election. Today's smaller, sleeker designs should greatly decrease the cost, and the writers of this report do not find that to be a precedent for Santa Cruz.

Interestingly, the community alongside the PRT route has not resisted it. In fact, in 2004 a revitalization plan for the Sunnyside neighborhood in Morgantown suggested adding a PRT station for their neighborhood and extending the PRT farther into the city. Of eight action items from the report, number four called for a feasibility study for the PRT station.

B. Advanced development – ULTra

The ULTra system is the PRT system furthest along in its development. They have begun construction of a system at London's Heathrow Airport. The company reports hitting all milestones, and recently the first support posts were put into place. ULTra has been operating on a test track in Cardiff, Wales, since 2002.

Aerial view of ATS test track

The ULTra design is focused on simplicity and low cost. It uses battery-powered vehicles that navigate extremely accurately using dead reckoning and remote sensing. The vehicles are designed to follow a dedicated right of way, and that path can be placed at grade or elevated.

In addition to the typical characteristics of a personal rapid transit system, the ULTra PRT design includes benefits such as relatively low initial cost, relatively low installation height, a proven prototype and test track, and continuing investment in the design.

Development

Developers of the system, United Kingdom-based Advanced Transport Systems (ATS), have been running a one-half mile test track since 2002. In 2003 they passed safety testing and earned consent from the United Kingdom's regulatory authority to carry the public.

In 2005 the airport company BAA, owner and operator of seven airports in the UK, signed a contract with ATS to introduce ULTra PRT into Heathrow airport upon the completion of certain

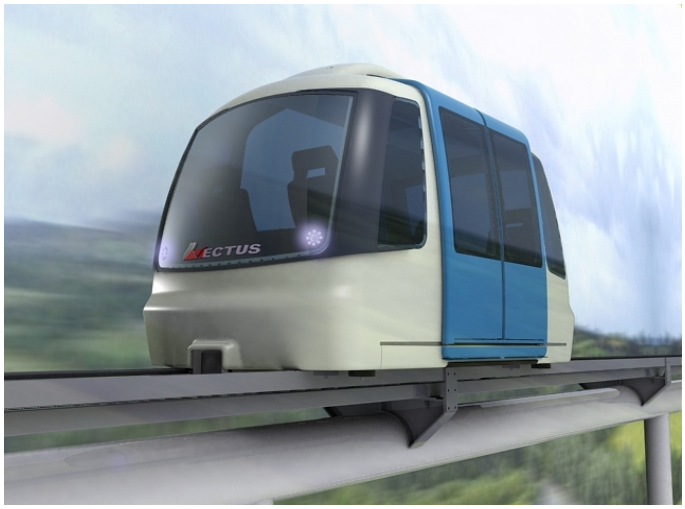
milestones in product development. This was accompanied by a financial investment in the company. Since then, ATS has reported steady progress and has specifically reported meeting all the milestones due in the BAA contract.

If the milestones continue to be met, the first commercial application of ULTra would be transporting people to and from distant parking lots with approximately 2.5 miles of guideway and 18 vehicles. Future expansions are planned to encompass the entire airport and into surrounding areas. BAA cited improved customer service, the ability to use existing infrastructure to provide new transportation and the reducing of emissions from ground transportation as reasons for their investment in ULTra.

Company:	**Advanced Transport Systems, Ltd.**
System name:	**ULTra**
Website:	http://www.atsltd.co.uk
Location:	Bristol, England
Vehicle Capacity:	4-Person
Grade of Travel:	At Grade or Elevated
Operating Speed:	25 mph (demonstrated)
Operating Headway:	
Guideway Type:	Concrete Trough
Power Source:	Batteries (in vehicle)
ADA Compliant:	Yes
Development Progress:	Operating test track and airport contract
Developer's Estimated Cost (USD/Mile):	$9-15 Million

C. Advanced development – Vectus

Vectus, a spin-off company of South Korean steel giant POSCO, is designing and building a personal rapid transit test track in Sweden. The company is based in the United Kingdom with offices in South Korea and Sweden.



Recently the prototype vehicle bogey made its first run around the test track. The company is following a cautious development and test cycle. They are first focusing on markets in Northern Europe and in Asia, and it is unknown when they would be ready to come to market in Santa Cruz.

One of the greatest strengths of Vectus PRT is that they can utilize the resources of their over $25 billion parent company POSCO. This design is much more advanced than the ULTra system, designed for higher speeds and tighter headways. In comparison with the simplest PRT designs, the Vectus design is expected to have more expensive guideways due to the motors being mounted within them, but this should allow them to have vehicles that are more passive and less expensive than some other designs.

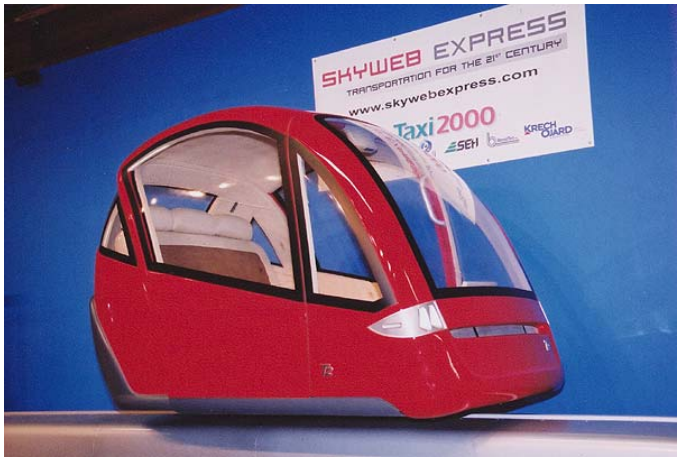
Development

POSCO chose PRT as a strategic business item and began research and development in 2002. In 2005 Vectus was formed as the company to continue PRT research and development for POSCO. Vectus has a one-tenth scale test track in Korea. The quarter-mile test track in Sweden has been completed and testing has begun. The ambition is to receive approval from the Swedish rail agency in mid-2007 verifying that Vectus's PRT product fulfills applicable norms and safety requirements. This certification could serve as template for future PRT installations around the world.

Company:	**Vectus**
System:	**Vectus PRT**
Website:	http://www.vectusprt.com
Location:	United Kingdom, South Korea, Sweden
Vehicle Capacity:	4-Person
Grade of Travel:	Elevated
Operating Speed:	37 mph (planned)
Operating Headway:	
Guideway Type:	Rail
Power Source:	Electricity from rail
ADA compliant:	Yes
Development Progress:	Test track under construction
Developer's Estimated Cost (USD/Mile):	$18 Million

D. Advanced development – SkyWeb Express

SkyWeb Express is a form of personal rapid transit developed by the Minnesota-based company Taxi 2000.



In addition to the typical traits of a personal rapid transit system, SkyWeb Express is designed to operate at high speeds completely above urban traffic. SkyWeb Express vehicles are designed to carry three adults. This reduces weight and allows the overhead guideway to be just a little more than three feet wide and three feet tall. The vehicles are powered by linear induction motors, which allow precise handling and control. This allows the system designers to plan for extremely short headways between vehicles, ultimately one-half second, making this an extremely high capacity system.

Weaknesses of this system include the installation costs for an elevated system and the need for specialized equipment to remove passengers from the elevated vehicles in the event of a system failure. In addition, with the system proposing new combinations of both hardware and software, considerable testing will need to occur.

Development

Taxi 2000 has one prototype vehicle, a test track 60 feet in length with loading and unloading platforms, and a scale model with 20 small vehicles for testing operational software. The company is continuing its development through funding from private investors.

Company:	**Taxi 2000**
System:	**SkyWeb Express**
Website:	http://www.taxi2000.com
Location:	Minnesota
Vehicle Capacity:	3-Person
Grade of Travel:	Elevated
Operating Speed:	20-60 mph (planned)
Operating Headway:	
Guideway Type:	Rail
Power Source:	Electricity from rail
ADA compliant:	Yes
Development Progress:	60 ft test track and small scale test track
Developer's Estimated Cost (USD/Mile):	$16-24 Million

E. Advanced development – Frog CyberCab

Frog CyberCab is a development of The Netherlands-based 2GetThere Automated People Mover Systems. While not a pure PRT system because it handles people in groups, it is included in this report because it is the most completely advanced system, with multiple installations running successfully.

"FROG" is an acronym for Free Ranging on Grid. This is a technology consisting of automated vehicles that drive in the same areas as people and automobiles. The automated vehicles themselves are packed with sensors to stay on track and avoid obstacles. These small four-person cars can be powered by batteries or a small engine.

A Frog system operates mostly at grade and at slow speeds. The current installations are most similar to a ground-based elevator, as no route switching is required, but the company reports that a route switching capability is planned.

Frog CyberCab Development

Frog has considerable transportation experience. Its fleet of 160 self-guided vehicles move container freight at a shipment hub in the Netherlands. Their guidance and control system was used in the creation of the Phileas semi-automated bus developed by the consortium APTS. A larger version of CyberCab, the ParkShuttle, is an automated mini-bus that can be used as a short-distance shuttle. The ParkShuttle has undergone passenger trials in Europe and is currently in operation carrying passengers in a business park application.

Even without a product for city-wide PRT service, Frog has a number products that could be suitable for parts of Santa Cruz, such as a beach-area circulator, a beach-to-downtown shuttle, a circulator at the university, or a shuttle between the university and parts of the city.

Company:	**2GetThere Automated People Mover Systems**
System:	**Frog CyberCab**
Website:	http://www.2getthere.nl
Location:	The Netherlands
Vehicle Capacity:	4-Person
Grade of Travel:	At-grade or elevated
Operating Speed:	12-19 mph (proven)
Operating Headway:	
Guideway Type:	Pavement with magnets
Power Source:	Batteries (in vehicle) or gas-electric engine
ADA compliant:	Yes
Development Progress:	In operation as circulators
Developer's Estimated Cost (USD/Mile):	

F. Early Stage – MicroRail

MicroRail is a design from the Texas based Megarail Transportation Systems. The company has proposed several versions of its transportation, including one named Megarail that is suitable for transporting automobiles on automated pallets. In this report, we are only referring to Microrail, its smaller PRT offering.

Microrail uses four passenger vehicles on a flat, wide guideway so that passengers are able to exit a stalled car and simply walk to the next station in the event of a system failure. The vehicles are powered from the guideway.

MicroRail Development

Much of the design work for MicroRail has been completed. MicroRail has not entered the testing phase, but prototypes have been built. A single section of the guideway was built to show how the mock-up vehicle and emergency escape would look. Steering and switching systems have been demonstrated using a small-scale prototype.

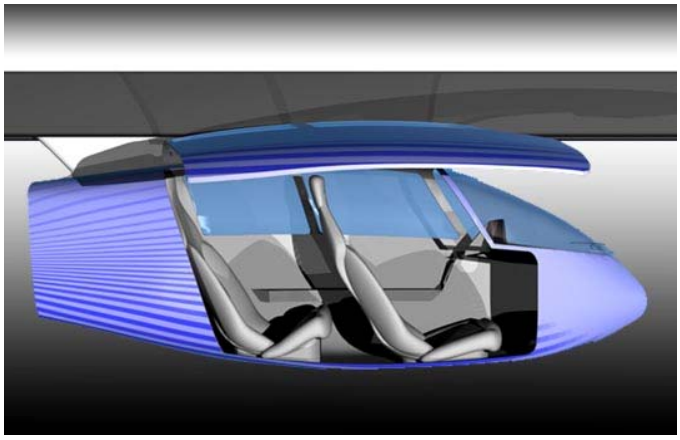
www.megarail.com

G. Early Stage – SkyTran

SkyTran is a form of personal Rapid transit marketed by Montana and California-based UniModal. If SkyTran materializes into what the designers claim, it would be an extremely efficient and fast form of personal rapid transit. UniModal claims that this design of PRT would be able to travel at 100 to 150 mph and operate at an energy efficiency equivalent to that of a 200 mile-per-gallon automobile. SkyTran's strengths are high energy efficiency, high speed, low cost, and an extremely small footprint. One drawback to this design is the need to get people comfortable with tandem seating, extremely high speeds, and small interior space.

SkyTran Development

This design has no test track or operating prototype, but does have an experienced design team. Other technologies that come from UniModal include a record setting fuel-mileage commuter car, the world's fastest electric car, and various other defense and aeronautical achievements.



One area for concern is the company's plan to not accommodate wheelchairs in the vehicles but to have separate transportation options for the disabled. This will need to be cleared by the Access Board, the policy setting board in Washington, D.C.

www.unimodal.com

H. Early Stage – JPods

JPods is an early stage system. There is a prototype vehicle that has been demonstrated in Santa Cruz.

The JPods website identifies a large number of innovations in the system design, which could make delivery schedules longer and more uncertain. The company has expressed willingness to install a simpler design where necessary.

www.jpods.com

6. Route Selection

In the previous section we asserted that PRT cannot be evaluated simply as a generic concept, but you must evaluate a particular technology. Similarly, even a specific technology cannot be evaluated accurately until it is placed into a specific setting. Size, speed and cost will all affect its value and usefulness.

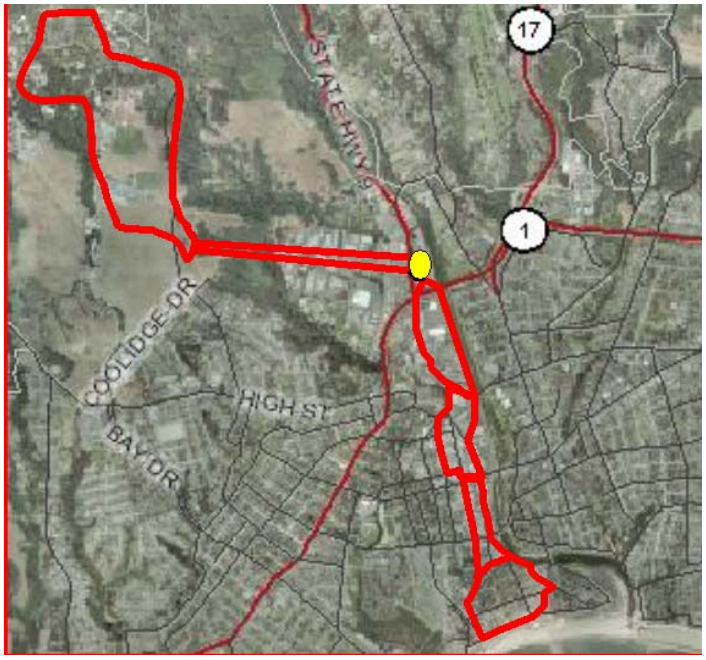
The most important factors in measuring the value of any transit system are its route and its stops. These determine whether the system can reach many riders at their origins and deliver them quickly to their destinations.

In Santa Cruz, a PRT system would pass through three distinct areas: the beachfront, the city – especially downtown, the Harvey West Park area, and the east end of the University of California at Santa Cruz campus. Each of these areas offers a mix of opportunities and tradeoffs in choosing a PRT route, and they will be discussed individually.

A. Complete system

The ultimate vision for the PRT system is to provide fast, convenient transportation between all of Santa Cruz's transportation hot spots. This means connecting the university, downtown, and beach into a seamless transportation network, integrated with the local bus system.

PRT advocates envision a day when university students would prefer not to have a car, as a PRT ride to downtown Santa Cruz is faster and easier, without the parking hassle. Downtown workers can access their jobs more easily, most likely beginning with a bus trip from their home, connecting to a "horizontal elevator" to take them to their building, or at least to their block. Then, daytime trips around downtown can be made without a car, either on foot for short trips or by using the PRT for longer trips. Finally, beach visitors have a better experience, with fewer parking headaches and opportunities to see more of Santa Cruz during their visit.



Sample PRT network connecting to a central bus/PRT transit center.
At 35 MPH, the longest trip would take approximately nine minutes.

To make this happen, the PRT system has to deal with three separate routing challenges.

B. Beachfront options and concerns

The Santa Cruz beachfront is an extremely popular tourist destination, attracting 3 million visitors a year. It is a source of considerable traffic frustration – both for visitors trying to reach the beach, and local residents trying to reach other destinations near the beach.

Politically, any path that provides access to the beachfront is a prime location for PRT deployment, as it could serve a significant transportation need. Combined with intercept parking near Highways 1 and 9, a PRT system could eliminate a large number of automobile trips.

The beachfront may also offer desirable opportunities to fund a system through public/private partnerships. A single private company, the Santa Cruz Seaside Company, operates the majority of tourist-attracting business in the area. The Seaside Corporation also owns or controls several parcels currently used for parking that would offer the potential for redevelopment if parking were shifted offsite. A partnership with the Seaside Corporation would be essential in order to

develop an effective beachfront transportation strategy with PRT. No one single model exists for establishing a partnership between the city and the Seaside Corporation, but the city would be wise to begin a conversation in the early stages of any PRT investigation. The authors of this paper have not been able to discuss these issues with the Seaside Company, but PRT advocates have found them to be receptive to the idea.

In addition, the Santa Cruz beachfront may offer a prime location for a private company to build a demonstration site for their PRT system. Santa Cruz is a well-known, world-renowned destination, and it is easily accessible by flights to San Francisco and San Jose. The seasonality of the beachfront may actually increase the location's attractiveness, as a PRT company can test their system under busy conditions during the summer season, then use the winter season for further testing and modifications.

While the beachfront is a popular and congested transit destination, there is a major concern of PRT deployment in the area. If an elevated PRT system is chosen, this would affect the ocean views of at least a few residents or properties. To some degree, this is a political choice, attempting to offset the negative impacts of the elevated structure with the overall positive impacts to the area. Financial compensation may need to be offered those whose views are affected. Below, we show routing alternatives to minimize this problem. In addition, it is possible to consider PRT in a non-elevated mode in this area.

Route Option 1: Intercept Parking

Under this first scenario, PRT eliminates traffic along Beach Street through the creation of an intercept parking area near the intersection of Highways 1 and 9. Visitors would be strongly encouraged to use this option rather than drive to the beach. In this case, the PRT line is serving a shuttle function and only needs to make one or two stops along the beach. This is a simple scenario and one that should be achievable for most developers.

In the drawing below, we are focused only on the possible route along the beachfront. Access to and from the intercept parking will be examined in a later section.

This route uses approximately 1 mile of track and includes two stations. There are no tight turns, no serious grade changes or other difficulties. It is a good candidate for future extensions along the beach or toward the city.

Because it would serve a beach crowd, which typically includes a number of family members plus items such as coolers and chairs, some of the smaller PRT vehicles may not be the best option. Family groups may be split into two vehicles, but the minimum size might be one adult, two kids, one cooler, and a beach chair.

Route Option 2: Beachfront Only

A simple route along the beach could serve as a demonstration site without serving a significant transportation function. With three stations, it would serve to facilitate movement up and down the beach.

As drawn, the system has tight turns that would require low speeds, and it may be that not all systems can operate this way. Also, even if the system can meet these requirements, vendors may not want to show this short linear alignment as the example of what their PRT system could be. An elevated option would interfere with at least some views, and that must be taken into consideration.

In our interviews it was suggested to combine a PRT system with a reconfiguration of Beach Street, allowing a PRT or other automated transit system to cruise along at grade. The new configuration would narrow Beach Street, creating a wider pedestrian promenade and opening the beach and boardwalk area to a greater variety of entertainment.

For most versions of PRT, it is most likely that the PRT would be sunken slightly into the ground, allowing numerous pedestrian ramps to cross the PRT path, making sure it is not a barrier. Some automated systems, such as Frog, can even mix with pedestrians at slow speeds.

Route Option 3: Demonstration Line

In this alternative, a short demonstration line is built on the land that is currently used as parking for the Seaside Company. The demonstration line runs at least 500 feet and up to 1,000, and likely should have room for one diverge and one merge intersection.

This would most likely be a temporary setup strictly for demonstration purposes. However, this line could serve as a single link in a future expansion, or the facilities in place here could serve as the maintenance and operations center for a future system.

Route Option 4: Demonstration Loop

For long term planning, the best initial design is a loop that can first test and demonstrate the key elements of personal rapid transit, then be expanded to serve other parts of the city. Shown below is one such proposal.

Containing approximate 1.7 miles of guideway, this route would service the beachfront in a way that allows for future expansion. As a grid spread over two blocks, it also offers choices for where to place the facilities that would accompany a full PRT system.

This is expected to be elevated, but portions along the beachfront could possible be at grade. Away from the beach, interaction with automobiles is inevitable, so only elevated systems are recommended for that area.

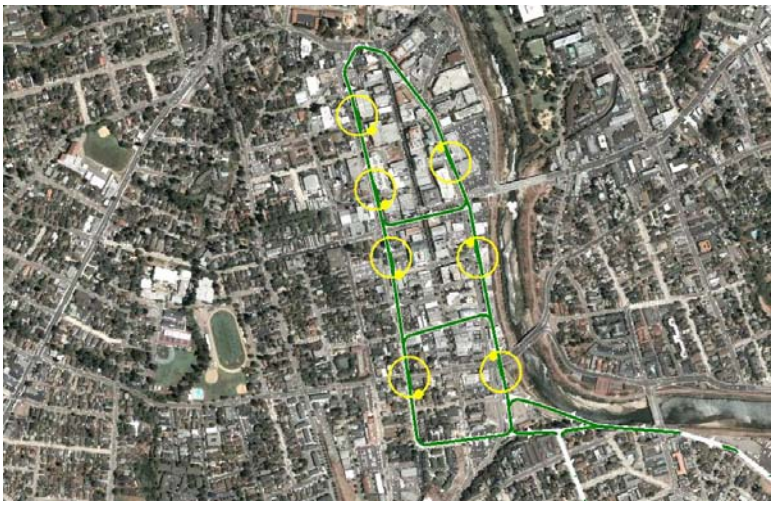
C. Downtown/city options and concerns

The beachfront offers several options that are relatively straightforward. Downtown, on the other hand, offers several distinctly different options, each of which has its own strengths and weaknesses. For North-South travel through the central business district, four options exist: Cedar, Pacific, Front, and along the levee.

Route Option 1: Cedar and Front

One option is to run lines along Cedar and Front with two crossovers. The crossovers save energy and reduce time when your destination is a few stops "backwards" on the clockwise circulation of the loops.

With seven stops as shown, virtually all of downtown can reach a PRT station with the longest walk being 150 yards. This makes it easy to get around all of downtown without driving, and it creates an easy connection for beach visitors. This, in turn, could stimulate additional shopping and dining opportunities while visitors are in town.



This route does bring challenges of where to place stations and where an overhead structure can be placed. Due to the high concentration of traffic, at-grade solutions are not recommended, so elevated structures would be required.

Option 2: Pacific

Another alternative is to replicate the map above, but make one of the North-South legs run along Pacific instead of Cedar or Front. This more closely aligns the transportation system to the walking and driving needs of the users, as Pacific is the main business street of downtown. For visitors, a run along Pacific Avenue would feel much more like getting a look at the heart of Santa Cruz, and it would expose them directly to the shops and restaurants there.

This route is along a more crowded corridor, so it will be somewhat more difficult to place the guideway and stations. Also, there are trees – predominantly along the east side of Pacific – that should not be disturbed.

Option 3: Levee, Elevated

If it seems impossible to bring an elevated line along Cedar or Pacific, an elevated line along the levee provides the lowest impact solution, although it is much less accessible to downtown. The levee offers a steady grade with little or no overhead obstacles. Few sightlines of the ocean exist along the levee that would be threatened by an overhead structure. Still, appearances do matter, and careful attention will have to be paid to the guideway design and appearance.

One variation of a levee path would have the two north-south lines on opposite sides of the river. Another variation would run a line along the west side of the river and then return through the city on either Pacific or Front. A final variation would run a line along the east side of the river and then return along Pacific or Front.

The size and weight of a PRT structure is small, somewhat greater than a light post but even smaller than a pedestrian bridge. The Corps of Engineers and other agencies would need to approve a design such as this.

Option 4: Levee, At Grade

For systems such as Frog and ULTra, a line along the levee offers an interesting alternative. Rather than run overhead structures, they could run at grade, adjacent to the existing bike and

pedestrian paths. To do this, a pier system would likely need to be built extending over the river path, and this will require certification that it will not impede water flow.

This option faces a question of what to do when it reaches Soquel Avenue and at the bridge to San Lorenzo Park. One alternative is to go overhead at the intersection, which would require a bridge of approximately 160 feet in each direction. A second alternative would be to go under the bridge, below the grade of the levee's edge. This would leave the guideway vulnerable to being covered in a flood, but the simple guideway designs of ULTra and Frog should allow them to return to service quickly once the water recedes.

A final alternative, seen in Frog's Schiphol Airport installation, would be to cross the paths like a railroad crossing, with one exception. Rather than transit vehicles always having the right of way like a train, the transit vehicles would wait their turn, then travel as a group through the intersection, making it function like a red light. At Soquel, this turns the intersection into a five-way stop, where there are turns for all four directions of traffic, then a turn for the transit vehicles. While this will increase travel times and decrease the system capacity, for systems of low or moderate demand it will have a significant impact on travel times, ridership, or system capacity.

Recommendation

Stations along the levee are very much out of the way, and out-of-sight is often out-of-mind for people making short distance trips. Even if it's just a few blocks, they will end up using their car. For these reasons, having both paths along the levee is seen as undesirable unless the difficulties of bring a line through the city are insurmountable.

Instead, a line along Pacific or Front Street would be the preferred north-south path. While Cedar is the preferred return direction because of its proximity to residential riders, the levee would be a reasonable alternate if Cedar was found too difficult to access.

D. University options and concerns

Accessing the university is a third distinct challenge. This can be separated into two different transportation needs: access to the campus and circulation around the campus.

Currently, the University of California at Santa Cruz has done a commendable job of reducing traffic to the university. Aggressive traffic control policies restrict on-campus parking permits among freshmen and sophomores. In addition, more than 40% of students live on campus. These conditions reduce the number of single occupancy vehicles on campus.

However, many Santa Cruz residents see the level of university traffic on neighborhood streets as too high. With the university considering expanding its size, some people feel that the resulting increase in traffic to and from the university will be the tipping point to unacceptable traffic conditions.

Campus Circulation

Circulation around campus is currently served by a fleet of shuttle buses. These have lower up-front costs than any fixed guideway systems, but PRT advocates point to the lower potential operating costs – as well as better service – of PRT systems as reasons why PRT may still be the better long-term solution.

A first question to resolve is whether PRT can handle the capacity needed on the UCSC campus. Again, this is an area where each system's capacity needs to be evaluated separately. In previous literature, Ashwini Tamhani, a master's degree student at the University of Cincinnati, planned a PRT network for that campus and showed that a PRT system with 2.0 second headways between vehicles could meet the performance of a comparable shuttle bus system serving 3,500 students over a two-hour period. In the Cincinnati work (currently unpublished), the average rider travels two miles, considerably farther than the average cross-campus trip at UCSC. Thus, a PRT system should be able to support a much higher ride count at UCSC than in Cincinnati.

Given the wooded nature of the university campus, an elevated PRT structure is a significant change to the campus. To minimize the construction impact, the PRT guideway could travel

along the side of existing campus roads. However, to serve the students, faculty and staff in the best possible way, the PRT lines could go even closer to buildings. Where it is deemed safe from an architectural and security standpoint, some PRT stations could be directly integrated into campus buildings.

As an alternative to an elevated structure, the PRT system could run at grade. To do this most efficiently, a PRT system such as Frog or ULTra could be given one lane of the existing campus thoroughfares, or new pathways could be cut alongside the existing walking and bike paths that cut through the campus. Some interaction with pedestrians and vehicles would still be required, and these can be addressed either by barrier gates, overpasses, underpasses, or, in the case of Frog, by the vehicles' sensing mechanisms.

7. Funding Options

For any community, a transit system such as light rail is a major investment, sometimes costing over one billion dollars. For a small community like Santa Cruz the costs are lower, but the obstacles to raising the funds are the same, if not more intense.

Several options exist for financing the investment for a PRT system. The small cost of PRT and higher expected ridership will help the prospects for funding, while the uncertainty surrounding a new form of technology will be an obstacle.

A. Federal New Starts Program

The traditional option for financing a fixed guideway transit system is the federal New Starts program. This program usually funds 50% of the cost of construction of a rail transit system, provided that the other 50% of funds are provided from funds outside of the New Starts program. These funds can come from the municipality, the state, the private sector, or even other federal programs. In addition, contributions can be either direct or in-kind, allowing staff time and land grants to be considered part of the city's matching funds.

Communities that procure traditional rail systems find this process to be very long and time consuming. Often they benefit somewhat from funds that are spent over the years to study the various alternatives that must be considered as part of the federal process.

The New Starts program has no conditions that would preclude funding for a PRT system. In recent years congressional earmarking of funds for particular projects short-circuited many of the criteria for the program. However, the Federal Transit Administration has attempted to rein in these abuses with more stringent requirements and a ranking system. Strict criteria should allow a low cost, high ridership PRT system to perform well in the rankings.

Regardless, the process would be slow. PRT vendors looking for an initial U.S. city to demonstrate their technology are likely to find the New Starts funding cycle too slow to meet their needs. However, there is an alternative federal program that could be used to fund the system

B. Federal Small Starts Program

In 2005 Congress passed the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), which created a new method of funding smaller fixed guideway projects. The Small Starts program can fund up to $75 million of the costs of transportation projects that do not exceed $250 million.

This procurement method should be simpler and more direct, making it compatible with the needs of both Santa Cruz and the PRT vendors.

As of October, 2006, the Small Starts program is still in the rulemaking process by the FTA and has not issued grants. Therefore, precise details of the funding procedures are not yet available. It is recommended that the city monitor the evolution of this program. An inquiry can be made to the FTA at any time.

C. Private

Private funds are being increasingly used to fund transportation projects. These investments range from 100% private financing of transportation systems in the hopes of making profits from tickets or tolls to the partial subsidization of a public-sector transportation system through land development around stations. Of these methods, a few seem likely candidates for assisting the funding of a PRT system in Santa Cruz.

First, the private sector company with the most to gain is likely to be the PRT vendor itself, particularly if Santa Cruz is the site of the first PRT system in the U.S. In that case, the vendor would gain a high-profile demonstration site in a popular tourist destination. This would allow them to show how PRT can work in with regular commuters in town, student and faculty commuters at the university, and with tourist traffic at the beachfront. An installation in Santa Cruz would also illustrate the system's ability to handle steep grades and various weather conditions.

In addition, Santa Cruz could obtain private-sector funding from private developers if additional land were converted to residential or office uses, or if a commitment to reduce the traffic impact through the use PRT and bus resources made it feasible for the city to allow denser development than would ordinarily be permitted.

Finally, to the extent that a PRT system directly benefits the Seaside Corporation and other tourist attractions, these could be asked to support the development of the system, possibly by taking responsibility for stations and/or guideway built to their properties.

In more than one interview with Santa Cruz residents, the idea of adding intercept parking near the intersection of Highways 1 and 9 could create a funding source. Intercept parking at this location could allow the redevelopment of a number of parking areas near the beach. In addition, a small auto-free community near the parking would bring in higher tax revenues than the [I-3] industrial property common in that area.

D. Public-Private Partnership

It is unlikely that any one funding scheme would be sufficient to pay for a PRT system in Santa Cruz. Therefore, a combination of public and private funding will be needed. Numerous models exist for such partnerships, but one new option exists for Santa Cruz, and that is to become a demonstration site for a vendor's PRT system.

If Santa Cruz were to host the first PRT installation, it is possible that a PRT vendor could provide funds for the first small portion of the system. Future expansions could also be done on a cooperative basis. The terms would have to be negotiated directly with the vendor, and no general rules apply.

There are certainly some disadvantages to a vendor choosing Santa Cruz as a demonstration site. The proximity to the salty air of the coast could be a deterrent, and the increased engineering to accommodate the area's seismic requirements will definitely increase costs. Also, the city's streets are rarely straight, and this could add cost and complication to a vendor's proposal.

However, the advantages of having a world-famous, picturesque community for visitors to see could easily outweigh these concerns.

For Santa Cruz to be in a strong position in these negotiations, the city should commit in advance to making PRT possible in the community. This includes the simple steps of updating any planning documents and zoning requirements that would conflict with the building of a PRT system. It would include obtaining cooperation from relevant other jurisdictions, including the county, the Association of Monterrey Bay Area Governments (AMBAG), the Regional Transportation Commission (RTC), and the State of California. By demonstrating a willingness to cooperate with a PRT vendor's goals, Santa Cruz could easily become the desired destination of one of these companies.

E. Philanthropic

A final, non-traditional, option exists for funding a demonstration system in Santa Cruz. Philanthropic funds from foundations or individual donors can be used to fully fund the system, or they can provide the non-federal matching needed for most federal government grants. These would likely be invested as part of a larger philanthropic endeavor, probably in connection with a greater emissions reduction effort throughout the area.

8. Implementation Options and Next Steps

The funding options listed above warrant further investigation to see whether they are applicable to the situation in Santa Cruz.

A. Demonstration site

One idea that has gained a small amount of traction is for a partnership of the City, the Santa Cruz Seaside Company, and a PRT developer to agree to built a short demonstration track near the boardwalk.

It has been suggested that this could be short, straight line track from 400 to 1,000 feet in length. This would give the developer a chance to prove basic components of operation and give the public a limited ability to see and ride the system. In this capacity it would function more as an entertainment ride than a transportation system, but there is the potential that it could be the basis for building a larger transportation system in Santa Cruz.

The Seaside Company has expressed a certain level of interest in hosting the facility, provided that it does not interfere with the parking and entertainment they currently offer. This has been seen by PRT advocates as an extremely positive step.

It should be noted that not all vendors are interested in a small preliminary demonstration site. The developers with full test tracks already underway may not see value in building a demonstration with only limited functionality. Thus, Santa Cruz would be most appealing to those developers who are early in their development process. While this represents an opportunity for the City to get in on the ground floor of a company's development, it also means that future expansion will have to conform to the development schedule of this company.

In order to make the demonstration attractive to more established companies, it could be linked to a follow-on larger scale project and the potential for the vendor to retain farebox revenues for an extended period of time. Thus, if the initial demonstration meets predetermined goals, the

vendor would be given the opportunity to expand the system and run it for a fixed period of time, retaining some or all of the revenue.

The next steps would be to solicit interest from PRT developers. Before a Solicitation for Expression of Interest could be published, the City (or, potentially, PRT advocates) should more tightly describe what is being offered by answering questions such as these:

- What right of way is available? Where is land available for a PRT control center?
- Under what terms can it be used?
- What construction permits are needed?
- What times of the year can the construction be carried out?
- How is power supplied to the facility?
- Where would the facility's workers park?
- What requirements will the State of California's Division of Occupational Safety and Health impose on the system if it offers rides to the public?
- What expansion possibilities could follow a successful demonstration?
- What ridership can reasonably be anticipated?
- What range of fares could be charged?
- What type of long-term agreement could the city benefit from?

With information like this, contact can be made to the vendors to assess their level of interest.

B. New Starts / Small Starts Programs

For the New Starts program or the Small Starts program, the first step is to contact the Federal Transit Administration. This should be coordinated with AMBAG, as they are the metropolitan planning organization (MPO) for this area.

Make no mistake, strong political support will be needed for getting this funding, both within Santa Cruz and in Washington, D.C. Representatives Sam Farr and Anna Eshoo should be enthusiastic supporters, and the rest of California delegation in the U.S. House and Senate should be familiar with the project. This level of political support requires time and attention by the city's lobbying team and should not be taken lightly.

The Small Starts program is still in its infancy, and many details remain to be worked out. By starting soon, the City can ensure that its needs as a procurer of a PRT system are appropriately reflected in the implementation of the New Starts program.

C. Private sector investment

Interest in using private investment to fund transit systems has been building for years. Former U.S. Transportation Secretary Norm Mineta frequently called for increasing the role of private funding in transportation projects.

Opportunities for private investment have been increased by a number of government efforts. At the federal level, the Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA) established funding for federal loans and loan guarantees for private investment in transit systems.

These loan programs still require a private partner, and to be attractive any PRT project must still look good on its financial merits. For any demonstration project, the PRT vendor is expected to be one private partner. Additional funds outside the government sector might be found by considering the funding alternatives below.

Toll Road Model

The traditional method would be to build the transit system like a toll road, letting the private sector charge fees and retain these earnings to pay their loans and earn a profit. In addition to per-rider fees, other entities such as government, businesses or the university could pay for the service they are receiving. In addition, federal funds can be used to pay for a portion of the construction cost, thereby minimizing the need for a loan.

At this time there is not enough information to determine what ridership levels would be needed to support such a model. Given the lack of data on PRT system costs, construction timelines and maintenance needs, we believe it would be difficult to structure such an arrangement at this time.

Land Development Model

Another arrangement that is sometimes used to privately fund transportation improvements involves land development. Allowing new or additional development creates a value to developers. In most cases, this also imposes negative traffic congestion impacts on the nearby community.

As an alternative, the development could be allowed under the condition that very tight controls be placed on automobile use. The developer would be required to implement a PRT system as part of the development. This PRT system could then be expanded to serve the city as well.

The writers of this report are not aware of available land that could be easily developed. However, there is the possibility of more intensive use of land in the existing city, for instance along Ocean Street. Combined with intercept parking near Highways 1 and 9, a PRT system that began along this corridor could allow visitors to enjoy the boardwalk and downtown without impacting local roads.

The intercept parking could supply one source of revenue for the project, while the increased development is another source. With less parking needed along the beachfront, it is possible that additional entertainment options could be added to the Seaside Company's current facility in place of the current surface parking lots, thereby generating additional visitors and visitor revenue for the City and for Seaside.

Such a change in policy would require the political acceptance from Santa Cruz residents, some of whom are likely to oppose any change to current zoning. Advocates would need to convince them that the zoning changes were worthwhile not just from the point of view of global or national interests, but that it will also improve life on the streets and neighborhoods affected.

Philanthropic Model

A number of recent philanthropic initiatives have aimed to reduce the consumption of fossil fuels. Other initiatives have sought to reduce our dependence on foreign oil, decrease income inequality, and address a range of social and environmental goals.

It has been suggested that philanthropic funding could be used to build a PRT system in order to demonstrate an effective way to wean a significant number of people away from private automobiles into a more efficient transportation option.

This kind of partnership is not impossible, but it would likely require a more changes than just adding a PRT system. Such funding would be more likely as part of a comprehensive set of changes to the community. By embracing a variety of environmentally and socially friendly technologies and practices, Santa Cruz could become the world's test ground for such practices. Funding of a philanthropic nature could be found in Silicon Valley and elsewhere, while private companies might very well flock to the area in order to learn how consumers will react to these alternatives.

This model is about more than PRT, and requires a visionary who can bridge the gaps between government and the philanthropic sector.

D. Additional options

Without a doubt, countless ways exist to combine the interests of the private sector with the needs of the public sector. A more in-depth look at these alternatives could be studied at a future date, but at this time it is more important to begin discussing the needs and interests of the most critical private partner, PRT vendors themselves.

9. Concerns

A. Concern: Denver baggage

At times the Denver baggage handling debacle was cited as a fear about implementing automated systems. The situation in Denver certainly deserves analysis as an overall failure of project implementation.

However, before anyone takes it as an implication of automated systems in general, one should realize that there are other automated baggage handling systems in place around the world.

This is a failure of implementation, a true concern, but not one inherent in the technology. It should be noted that the vendor of the Denver baggage system warned the City at the outset that it could not complete the project in the allotted time. Care should be taken to minimize the city's risk and to ensure that the most competent project management teams are in place for any new technology project.

B. Concern: The FTA will not grant funding for unproven technologies.

There is a widespread belief that the Federal Transit Administration will not grant funds for transit systems unproven in public service. This is not true. The FTA reports that they will respond to requests from local government unless the rules limit the type of system that must be chosen. Currently, the rules for the federal New Starts and Small Starts program permit the funding of PRT systems. Where this misconception arises is that transportation studies frequently include a requirement that any system under consideration must be proven. This greatly reduces the extraneous load on the consulting team and ensures that the city will not be drawn into a situation where they unwittingly adopt an unproven technology and inherit the risks of its first installation. However, if the city is aware of the risks and is prepared to mitigate those risks through its contract with the vendor, the city can instruct the consultants to remove this requirement, and all systems can be considered.

C. Concern: Unproven systems are not safe.

The first concern of any vendor and customer must be safety. Safety techniques are well known, and automated transportation systems safely travel millions of miles each year. But while several recent accidents on automated systems have proven to be the result of human error, there will always be a realm of human/machine interaction, and the flaws of the human operators must be taken into account. It is incumbent on the manufacturer to effectively implement safety standards, and it is incumbent on the customer to ensure that this happens. For Santa Cruz, the State of California's Elevator, Ride and Tramway (ERT) Unit of the Division of Occupational Safety and Health will certify and inspect PRT transportation systems, and regulations of the California Public Utilities Commission will likely apply.

D. Concern: Reliability

Some PRT systems introduce new methods of switching, power and control that must be operated together for some time before reliability rates can be calculated. Also, as the number of sensors monitoring safety conditions increases, there is an increasing chance of a false-positive result. Depending on the design of the system, these could shut down or slow the operation of certain vehicles or segments of the system even when there is no real problem. Of course, while some PRT systems promote their high-tech and sophisticated image, other PRT systems have been designed to be almost as simple as a golf cart. Still, while these systems have reduced the number of new components, even these will need to operate for some time to assure the customer that they will meet the needed level of reliability.

E. Concern: Cost overruns

Depending on the method of financing, the City of Santa Cruz may be highly involved or not involved at all in the funding of the system. To the extent the City is involved, questions about the cost of the system will need to be answered. Cost-plus contracting could leave the City open to being responsible for cost overruns, while fixed-bid contracting would put the onus on the implementation team. Fixed-bids do not mean the City does not have to worry about the developer's cost, however, as it still remains important to ensure that the developer has the resources to continue with the program even in the event of significant cost overruns.

F. Concern: Earthquakes

As anyone who lives here knows, Santa Cruz is an active seismic area. The various PRT designs have different susceptibilities to seismic events. Each will need to make adjustments to their design in order to build their system in Santa Cruz. For systems operating at grade, it may be as simple as adding a module to their control system so that all vehicles can receive a "stop" signal as soon as a seismic event is detected. For elevated systems, substantial design changes might need to be made to the guideway and its supports. These are all challenges with solutions, but the difficulty may raise costs or be a disincentive for a PRT vendor to build a first system in Santa Cruz.

G. Concern: "Brick Wall" stopping requirement

There exists a rule that trains must maintain sufficient spacing when following another train so that if the first train hits makes an immediate stop (hits a "brick wall"), the second train can come to a full stop before the two trains would collide. If applied to PRT, this would increase the headways between vehicles and would decrease the system capacity.

This is not seen as a problem for Santa Cruz. This requirement could be a problem in dense cities where high demand requires that PRT match the demand of a rail system. It should not be a problem in Santa Cruz, where density is low to medium.

In high demand scenarios, PRT vendors would argue that this rule should not apply to PRT systems. PRT vendors are planning on using new methods of control that are different from the moving block control of the railroad industry. The new model of control will keep vehicles spaced safely, merge them smoothly, and direct empty vehicles to the places where they are needed. Research and development on these control systems will make continual improvements, and it may take some time before their maximum capabilities can be reached. The brick wall requirements may be a reasonable starting condition, but they should be reduced as a PRT system proves it can operate safely at lower headways.

H. Concern: Public reaction to overhead guideways

Another area that has not been proven is completely non-technical in nature. It is how the public will react to overhead structures that will likely be a part of any PRT implementation. While all PRT structures are tiny compared to most overhead vehicle paths, certain vendors favor structures that are more square (approximately three feet by three for the SkyWeb Express design), while others are wider but with a shorter height (approximately 6 feet wide by 2 feet high for the ULTra design). No structures of this size have been built in cities. Even pedestrian bridges are much larger than this. Thus, if you knew that a pedestrian bridge would be acceptable, you could conclude that the PRT structure would likely be acceptable. Still, there remain areas where the pedestrian bridge would not be acceptable, while a PRT structure might. And, parts of Santa Cruz are host to some of the most spectacular views in the world. Therefore, the public's acceptance of overhead structures – while not required by all PRT systems – is unknown at this time and could limit where overhead PRT systems are deployed. If a vendor of an overhead system is interested in coming to Santa Cruz, it is suggested that they ship a section of guideway to be installed in a public area in order to get feedback from the public.

As with any infrastructure project, uncertainties and changes will exist. It is important that the vendor be part of a team with good experience in the design and construction of public works projects.

Finally, it is important that the vendor's technology be available to third-party firms to provide service and support. At the very least, technical specifications and maintenance procedures should be held in escrow, so that there is the capability to take over the system in case the parent company should go out of business.

10. Conclusions

Interviews with Santa Cruz residents, city officials, politicians, and business leaders revealed a widespread curiosity about personal rapid transit. While there was some skepticism about whether the technology would live up to its promises, there was no hostility or opposition. Participants were in agreement that more information was needed.

Several courses of action are possible to follow up on the information provided here. One option is for the City to maintain an awareness of PRT but take no active steps to have it installed locally until it is proven elsewhere. However, it should be noted that Santa Cruz's small size means that once PRT is established, developers will probably be looking to sell their products in much larger cities and elected officials will likely look to solve larger problems first, and Santa Cruz may face a very long wait before they have a chance to procure a PRT system. Therefore, such a passive approach will likely prevent PRT from being deployed even when it becomes successful elsewhere.

A second option is a more activist approach, led either by private citizens or by government. There is certainly a role for citizen involvement. PRT represents a significant shift in public policy, and issues such as where to place the lines and whether the visual impact is acceptable are issues that deserve public input. However, support from local government is essential. Even a demonstration line funded fully by private interests will still need cooperation in obtaining permits and licenses. And requests for federal funds will require strong local support.

Thus, strong support from the City, the County, AMBAG, and METRO is essential for any financing plan to succeed. Typically this will further require a visionary leader to step forward and champion the cause. This could be a currently serving elected official, or it could be someone who steps forward from the business community or a retired official. Whatever the background, it will likely be someone who sees the potential of PRT and who has a strong desire to make a dramatic difference. This person should have vision, leadership, gravitas and experience. Such leaders are often found behind new innovations and new infrastructure projects, and the authors of this report feel such a leader is necessary to bring PRT to Santa Cruz.