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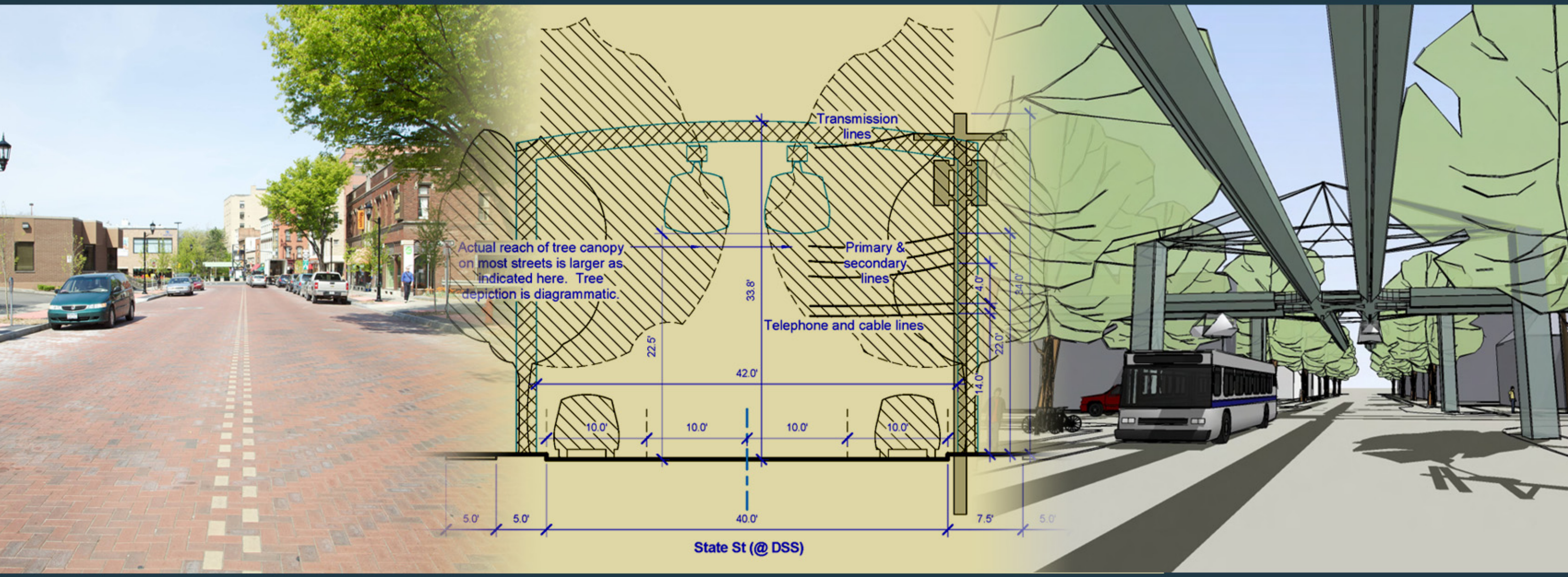
Department of Transportation



Feasibility of PRT in Ithaca, New York

Appendices

September 2010

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FEASIBILITY OF
PERSONAL RAPID TRANSIT IN ITHACA, NEW YORK
Final Report

Prepared for

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APPENDICES

Appendix A: Viability of Personal Rapid Transit in New Jersey

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Viability of Personal Rapid Transit in New Jersey
Conclusion to the FINAL REPORT; February 2007

Prepared for the New Jersey Department of Transportation
Prepared by Booz Allen Hamilton

PRT is an innovative transportation concept designed to combine the comfort and convenience of private automobile travel with the efficiency of public transit. It has the theoretical potential to provide a higher level of personal mobility than comparable transit modes at a potentially reduced capital and operating cost. It also holds the promise of being potentially more energy efficient, less land consumptive and more environmentally responsible while improving the overall service, speed and attractiveness of public transportation. Conceptually, PRT could provide a stand-alone network or be part of the larger multi-modal network of urban transit services.

Unfortunately, as documented in previous sections of this report, PRT has not yet advanced to a state of commercial readiness. Additional development work is needed. When considering what potential role PRT could play in New Jersey's transportation future, decision-makers must first understand the challenges that remain to system development and implementation. The development and implementation of PRT must be a long-term strategic initiative. Advancement of PRT will require not only additional technology development but also the development of a new and different business model to support the new transit technology.

- **Challenges to Implementation**
  PRT is an emerging technology and industry with limited support from the public and private sector. There are only a few small firms advancing the development of PRT technology. There are limited industry standards guiding PRT development and there is limited expertise and understanding of PRT concepts in conventional transportation consulting, engineering, planning and policy-making sectors. As an emerging technology, the market processes of product evaluation, acceptance, and standardization are to be anticipated before full technology maturation is achieved.

  Since there are only a few PRT systems in development and only one hybrid system in operation, any State or agency choosing to implement an initial PRT system will assume higher risks of system implementation and operation and may incur greater expense and other difficulties in addressing problems that may arise from public operation. The following challenges will need to be addressed as PRT development continues:

- **Engineering and planning expertise:**
  There is limited depth of experience or understanding in the transit industry regarding the advanced technology concepts central to PRT design and operations. This experience does exist, however, in other industries that support advanced technology development such as aerospace, automotive, defense, computing and networking.

  It will be important to draw upon the technology expertise from these industries and combine it with the operating expertise from the transit industry to develop an advanced, robust and "public ready" PRT system.

- **Open technology development:**
  PRT technology is currently under development by independent suppliers that are seeking to develop products that have a competitive advantage to other suppliers. This is a normal and advisable business practice in the early stages of product development. As the industry matures, it will be in the interest of potential customers (i.e., transit agencies) of PRT suppliers to encourage the use of open technology that avoids proprietary designs and vendor exclusivity.

  It will also be in the interest of potential customers to encourage the use of commercially available components to avoid specialized product development, unique support and maintenance requirements, higher costs, and less flexible and responsive operating environments.

- **Development and application of standards:**
  As a new technology, PRT could benefit from the development and application of appropriate performance and operating standards as the technology advances. Standards will be needed in various areas including safety, security and interoperability. It will be important to ensure that technology standards do not unnecessarily limit innovation and competition which could improve the performance of PRT systems overall.

  Conversely, it will also be important to guide the development of the technology with standards that protect the public's health, safety and welfare.

In terms of standardization, lessons can be learned from the past experience of the American Society of Civil Engineers which developed standards for Automated People Mover industry and the National Fire Protection Association (NFPA), which developed NFPA Standard 130 covering fire protection and fire life safety issues applicable to fixed guide-way transit and passenger rail system including Automated Guide-way Transit.

Additional analysis will be needed to determine the efficacy of applying current industry standards versus the development of new standards.

- **Intellectual capital management:**
  To provide for competition in the PRT marketplace, it will be important to seek multiple vendors with the capability to provide interoperable components and sub-systems. If patents are owned solely by the initial system provider, that provider may monopolize the market and set high prices for system extensions, upgrades and replacement parts. In addition to open architectures and interface standards, it will be important to foster sharing of key patented technology through licensing or other arrangements between vendors, suppliers and customers.

- **Institutional framework support:**
  Currently, there is minimal institutional infrastructure and expertise (i.e., experienced and knowledgeable design, operations and maintenance professionals within the conventional transit industry) to support the specialized analysis, design, construction and operations needed to implement PRT and ensure safety and security. This expertise can be acquired by retraining personnel, hiring additional staff or contracting with private firms, as appropriate, depending on the implementation agency's needs.

- **Consistent political, economic and technology support:**
  The development and implementation of an initial PRT system and the subsequent implementation of PRT in other locations will require a long-term commitment of financial resources. It will also require vision, innovation, and consistent political support.

  The history of PRT has many examples of development programs that started with good intentions but were halted due to changing political agendas, incomplete funding, inadequate engineering and economic analysis, inappropriate design standards, and many other factors. Specific attention should be given to the lessons learned from the Chicago Regional Transportation Authority (RTA) effort to develop a PRT system in partnership with the Raytheon Corporation.

  Changes in requirements, technology, political leadership and a clear commercial focus caused this program to fail. The lessons learned from these previous development programs can be used to simplify and streamline any future PRT development efforts but may not eliminate all potential pitfalls.

- **Conclusion: Options for New Jersey**
  The promise of PRT has been in the public discussion for over 40 years. It has not reached maturation for a variety of reasons but remains an enduring idea that offers the unique and rare combination of potentially improving the quantity and quality of transit service while reducing costs, congestion, and environmental impact. This opportunity is available through the innovative application of advanced yet commercially available technology in a new form designed for public transportation. PRT may provide an opportunity for New Jersey to develop a new mode of transportation that could meet urban transportation needs not currently met by conventional modes. It may also provide an opportunity to develop a new industry centered in New Jersey.
  The following options are presented for consideration by decision makers to advance the state of PRT and become a viable option to address transportation needs within the State of New Jersey:

Option 1 – Monitoring and support

Action:

- Play no active role in the development of PRT
- Monitor PRT development activities conducted by private developers and other governmental organizations around the world and reconsider the State's role in the future, as appropriate

Pro's:

- Requires no commitment of State funds
- Eliminates the risk of selecting sub-optimum technology configurations for early implementations

Con's:

- Limits the State's ability to influence the pace and direction of PRT development. PRT development activities may favor technology solutions not appropriate for New Jersey (e.g., technologies that operate best in fair weather climates)
- May prevent the State from capitalizing on an opportunity to develop a new PRT business/industry centered in the New Jersey Viability of Personal Rapid

Option 2 – Research and analysis

Action:

- Conduct New Jersey-based research in areas that will advance PRT development, including the use of tools, analysis techniques and data that support the development, implementation and operation of PRT systems

Pro's:

- Provides a foundation for effective demonstration and implementation of PRT systems in the State and elsewhere
- Could raise New Jersey's profile as a leader in helping to guide and shape new technologies and industries
- Helps to ensure that advancements in PRT technology are appropriate for New Jersey applications
- Provides a base of knowledgeable/experienced engineers, designers and planners to support the growth of a PRT industry in the State

Con's:

- With no commitment to implementation, research activities conducted in New Jersey may have limited effectiveness
- Exposes the State to some financial risk by investing in research that may not have tangible results in the short term
- Research occurring outside of a comprehensive systems engineering and development program may be of limited use
- Even with additional research, PRT developers may fail to secure investment funds resulting in little or no additional PRT development

Option 3 – Detailed application studies

Action:

- Identify potential PRT applications and conduct preliminary analysis of one or more applications including cost, performance, ridership, layout and potential community impacts
- Conduct public outreach, develop potential plans and secure public endorsement of PRT as a viable mode of transport

Pro's:

- Lays the foundation for realizing the theoretical benefits of PRT technology if development and demonstration systems prove successful
- Enhances PRT developers ability to secure private investment by creating a passive endorsement of the technology
- Creates an opportunity to educate elected officials and the public regarding the technology and its potential benefits

Con's:

- Requires commitment of State resources without any guarantee of tangible benefits
- May raise public and policy maker expectations before technology is ready for implementation

Option 4 – "Proof-of-concept" public/private program to develop and operate a pilot test track

Action:

- Help build, partially fund and support a public/private partnership to conduct a comprehensive program to develop and operate one or more test tracks to demonstrate PRT performance. The comprehensive program would include product design and engineering, prototype and component testing, construction of at least one full-scale test track, system testing for reliability and safety, and efforts to achieve commercial readiness. From previous PRT and similar development programs, it is expected that the program may require between $50 and $100 million depending on the selection of technology from previous and current programs and the degree of test track construction and testing.
- Establish shared risk, funding and ownership program with private and public partners to limit New Jersey's share of program costs
- Create mechanism to create institutional infrastructure for research, development, manufacturing, engineering and operational support within the State

Pro's:

- Provides New Jersey with the opportunity to demonstrate international leadership in shaping the future of the technology
- Provides an opportunity to structure program around New Jersey applications
- Provides an opportunity to create a network of engineers, planners, technology developers, manufacturers, and other organizations in New Jersey to foster the creation of a new PRT industry in State
- Provides an opportunity to distribute and share potential risks, funding and future rewards
- Shortens implementation time frame and provides a higher probability of success with an opportunity for the State to receive return on investment from revenue sharing and economic development

Con's:

- Requires the commitment of public funding to support the development partnership
- Given the nature of a public/private partnership, there is potential to develop sub-optimal technology solutions – as experienced in the Chicago RTA program
- Public/private partnerships are vulnerable to leadership change over time which could negatively impact success especially if political support weakens or technology development is delayed.

It should be noted that this development program would result in a full technology readiness and the ability for the State to begin implementations of the technology for public operation. It is expected that the test track from the development effort would remain an ongoing test and development facility for the partnership or a research university that may be part of the partnership. Additional funds would be required for operational systems for public operations.

Appendix B: Case Studies

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Case Studies: Morgantown/WVU PRT and London Heathrow BAA/ULTra

Morgantown/WVU PRT

ULTra PRT

Although many PRT designers have enjoyed an opportunity to scrutinize their system's components, control system and operating characteristics at a valid testing facility, only two traditional PRT systems have been commercialized to date; the ULTra PRT system recently installed at Heathrow Airport in the United Kingdom and the WVU PRT, in Morgantown, West Virginia; a long-time example of how PRT/GRT can serve to play an important role in enhancing an areas' mobility portfolio. The following is a short case study of each system:

A. Morgantown/WVU PRT[i]

Summary

West Virginia University Personal Rapid Transit (WVU PRT) is an Automated People Mover located in Morgantown, West Virginia, a community of approximately 30,000 residents. The enrollment at the University is approximately 19,000 students, with 7,500 university staff. The system connects the three campuses of West Virginia University and was built by the U.S. Department of Transportation and Boeing Vertol in the 1970s. It is the first of its kind in the world.

WVU PRT

To many who work in the field, it is actually considered a *quasi*-PRT system because it lacks some basic features of PRT, such as 100% on-demand service. Therefore, to help distinguish it from other systems in progress, it is often referred to as automated Group Rapid Transit (GRT).

An experiment in energy efficient public transportation at the time, it has now been in operation with first-rate reliability for over thirty years. The cost to ride the Morgantown/WVU PRT is nominal, to say the least. Included in undergraduate tuition and fees, students simply swipe their IDs at the station, while visitors and citizens only pay $0.50 to enjoy the bypass of parking and traffic hassles, earning it a reputation as the easiest, fastest, and least expensive mode of transportation in town.

History

In the 1960's, WVU expanded to a second campus two miles away that was served only by two hilly roads, causing major difficulties in mobility. At the time, buses shuttled students and staff back and forth between campuses, but they would soon experience severe traffic congestion. At one point, to reduce daily student travel, the university was forced to require students to take classes at only one of the two campuses.

To address the rising concerns over the escalating costs and losses in efficiency of public transit, the Morgantown/WVU PRT project was proposed in 1969 and was backed by U.S. President Richard Nixon as a demonstration project for modern rapid transportation. To fully understand the greater context, however, let us keep in mind the U.S. was also amid the first major OPEC oil crisis.

This pilot project was the result of several system studies in the late 1960s whose objective was to determine the most effective method of meeting the public transportation challenge in our growing cities and metropolitan areas. These studies identified the basic tenets of on-demand, personalized, origin-to-destination service as the basis to construct effective public transit systems into the 21st century. Initial prototype work performed by the Aerospace Corporation combined with private investment fueled the enthusiasm for this new type of transit.

What started out as a demonstration project estimated to cost between $15 to $20 million dollars quickly turned into a political chess piece in the presidential election campaign of 1972. Pressure applied by the administration to complete the project before the next election combined with the uncertainty of this new technology resulted in an approximately $130M system which took nearly a decade to complete and is much more awkward and cumbersome than many had anticipated.

Although not exactly what was initially designed, the system is regarded as a great success, having achieved world "firsts" for innovations being put into public service that include:

- First fixed guide-way transit switching via in-vehicle switching, rather than track switch.
- First "demand mode" fixed guide-way transit service.
- First transit control system whereby central control communicates to vehicles, providing automated vehicle control, via inductive wire loops embedded in the guide-way.
- First "moving slot" control system.
- First automated re-distribution of empty vehicles to match predicted demand

Operations

Morgantown/WVU PRT operates at between 98% and 99% availability. Currently, the total staff is 48 and includes a manager, four supervisors and five operators. The maintenance staff includes a manager, two supervisors and 26 technicians. Support personnel include three engineers, three stores personnel and two business people.

Vehicles

The original fleet of vehicles is still operating. Each of the 73 vehicles used on the system weighs 8,760 pounds (3.97 t) and can reach 30 miles per hour (48 km/h). The network serves about 16,000 riders per day. The record for most riders in a day is 31,280, set on August 21, 2006.

The cabs contain eight fixed seats; four in a 'U' shape at the front of each vehicle and a matching four at the rear. In the center of the cars is standing room designed for twelve passengers, who are provided with four poles to grasp, giving each car a maximum capacity of twenty.

Vehicle features include automatic pneumatic leveling, a cabin heating/cooling system, welded steel frame, emergency exit rear window, impact collapsible front bumper, rigid rear bumper, emergency braking deceleration, and passive power collection from guide-way power rails.

Vehicles steer by means of side guide wheels that sense the location of the left or right guide-rail. Although the vehicles are built upon a steer-able rubber-tired platform, they do not navigate autonomously. The vehicles are controlled via communications from the station control center through the communication loops in the guide-way. The vehicles are directed either left or right at the appropriate speed and four-wheel steering is used to achieve a 30 foot turning radius.

The vehicles are maintained on a predetermined scheduled maintenance basis with 3,000-mile intervals. Additional tasks are accomplished at 6,000, 9,000 and 12,000-mile intervals. The propulsion motor is rebuilt every 90,000 miles; a schedule that essentially rebuilds the vehicle continuously.

Modes

The system has three modes of operation: Demand, Schedule, and Circulation. Demand and Schedule modes are designed to operate during times of peak demand and Circulation mode is used during off-peak service. The Demand mode attempts to capture the on-demand aspect of PRT, the other two modes are prescheduled vehicle operation patterns intended either to optimize throughput during peak demand or to limit operating expenses during off-peak hours.

Demand mode reacts dynamically to passengers' request for service. The algorithm governing the Demand mode balances two parameters, passenger wait-time and vehicle occupancy. Once a passenger enters a station and requests service to a destination, a timer starts. If the timer reaches a predetermined limit, typically 5 minutes, a vehicle is activated to service the request even if no other passengers have requested the same destination. Also, if the number of passengers waiting to travel to the same destination exceeds a predetermined limit, usually 15 people, another vehicle is activated to lend support.

Once activated, a vehicle opens its doors and an electronic display prompts passengers to board. The vehicle doors remain open for 20 seconds allowing passengers to board. The doors close automatically, and the vehicle departs to its final destination, avoiding any intermediate stations. The two parameters that govern the algorithm, maximum passenger wait time and vehicle occupancy, can be varied by central control.

In Schedule mode vehicles travel direct from origin to destination based on predetermined schedules. For high demand periods with well-known travel-demand patterns, Schedule mode operates slightly more efficiently than Demand mode. During peak demand periods, operating in either Demand or Schedule mode, the system transports approximately 1,500 passengers per hour. Historically 80% of travel demand is between the Beechurst and Towers Stations. Periods of peak demand coincide with the 20-minute period between scheduled classes.

The average wait for passengers traveling between Beechurst and Towers stations during peak demand is about 1 minute. If the system is in Demand mode, the 15-person rule is usually triggered after about 60 seconds. During the 20 seconds in which the vehicle doors are open, more passengers may arrive and board, often filling the vehicle to capacity. Wait time is higher at less busy stations.

During off-hours, Demand mode would result in many nearly empty vehicles traveling about the system. During periods of low demand the MPM switches to Circulation mode which operates like a local bus, stopping at each station along the route on a preset schedule. Passenger travel time to destination lengthens while the system operates more cost-effectively.

Performance

In the 2006 fiscal year, the PRT system broke down a total of 259 times for a total of 65 hours and 42 minutes, out of a total of 3,640 hours and 15 minutes scheduled running time, which equates to about 98% availability. Of those 259 breakdowns, 159 were caused by vehicle-related problems. Operators are working to improve efficiency by reducing this vehicle downtime.

Since the system's completion in 1975, technology for such systems has advanced considerably, while the control equipment for the Morgantown/WVUPRT has changed very little. The control room is said to resemble a NASA mission control room from the 1970s, though the underlying electronics are more modern. Despite these factors, the overall availability of service (98%) exceeds the original design specification of 96.5% availability.

Guide-ways

In contrast to many other automated people mover systems, the Morgantown/WVU PRT relies on rubber tires rather than rail for movement. Due to Morgantown's snowy winter climate, the concrete pathways feature embedded piping containing a glycol solution used to melt snow and ice. Several stations along the track help to heat the glycol solution.

The guide-way also houses inductive communication loops through which signals travel between vehicles and the control and communications equipment. These messages include a stop signal that generates a signal to decelerate and stop the vehicle ±6 inches from the loading/unloading platform gate. The loops also include a switch tone transmitter which signals vehicle to steer right or left. Calibration loops generate a signal to provide measured distance reference. This signal is used to calibrate each vehicle’s odometer.

Additional embedded loops facilitate communication with the vehicles to send performance level, braking command, door command, and identification request signals. Presence detectors are embedded into the guide-way and are used in the collision avoidance system. Power is distributed to the vehicles via high-voltage passive channel conductors. Although the guide-way was built using conventional standards, materials, and techniques, it comprised the majority of the cost of the system.

While portions of the PRT track are at or below ground level (35%), much of the system is built on elevated bridges and viaducts (65%). The viaduct spans are approximately 30 feet (9.1 m) in length. There are two distinct styles of viaduct in use on the system, with those constructed for the first phase being noticeably heavier-duty than those built for the second phase extension.

In order to enable the direct origin-to-destination service, each of the three middle stations, (Beechurst, Engineering, and Towers) have by-pass lanes and turnaround channels. These features allow each of the three middle stations to operate as off-line stations. Having by-pass lanes alleviates the need to stop at any stations between origination and destination.

This was a major advancement in mass transit concepts at the time, and still remains atypical of rail and bus service even today. Since the system is linear, the two end stations do not require by-pass lanes. Any vehicles utilizing these stations will, by nature, have passengers needing to disembark.

Control Systems

The Morgantown/WVU PRT was originally controlled by DEC PDP computers installed in 1971. Due to difficulty in procuring replacement parts, these older computers were replaced in 1997-1998 with Intel Pentium computers.

The entire control system is divided into four parts: *central, station, vehicle, and guide-way.*

Central Control collects destination service requests and distributes commands to the stations via 2400 bps modems links that connect central control with stations. The system features a large control room with 32 surveillance monitors, multiple computer consoles, and a mimic display that depicts the guide-way, tracking vehicles relative to each presence detector. A three-person crew operates the control system and a flexible voice communication system assists the crew.

The basic control concept is based on the moving slot scheme. Imaginary numbered slots, 15 seconds apart, travel around the main guide-way. Vehicles may only travel within one of these moving slots. In practice, expected vehicle position is checked against actual position at presence detectors.

Once a loaded vehicle's doors close, central control allocates a numbered slot to the vehicle. Acceleration from the station to the merge point with the main guide-way is timed precisely so that the vehicle enters the main guide-way at cruising speed within its designated moving slot. An occupied slot may be allocated to a waiting vehicle if the current vehicle plans to exit the main guide-way before the loaded, in-station vehicle merges onto the main guide-way. System operators are alerted when any vehicle positions are out of tolerance. Because portions of the main guide-way speed vary the distance between moving slots varies while the time remains constant.

Empty vehicle management is also an important aspect of the control system. In demand mode, vehicle demand at each station is estimated based on current passenger requests and past travel patterns. When a station shortfall is detected, empty vehicles are routed to the deficit station from surplus stations. At surplus stations, vehicles are first filled with any waiting passengers before departing for the deficit station. The minimum vehicle demand for each station platform is two, representing a policy of always having two available vehicles per platform.

Station Control processes rider destination requests, manages passenger displays, tracks vehicle status including door closing, and controls vehicle movement (speed, smooth stop in channel berth, switching – steer left or steer right, position calibration).

Vehicle Control responds to station commands to operate motor, brakes, steering, and doors.

Guide-way Control monitors inductive loops for the vehicle control unit antennae. Vehicles have one send antenna and one receive antenna. Inductive communication message types include: switching, stopping, and door operations.

Stations

The system connects the University's disjointed campuses with five stations (Walnut, Beechurst, Engineering, Towers, Medical) and an 8.65 mile (13.9 kilometer) track. All stations are designed as a two-level building. Passengers enter on the lower level and either climb stairs or ride an elevator to the boarding areas. The middle three stations have two boarding areas. At these stations passengers are directed to the appropriate platform by an electronic display. All stations are constructed so that pedestrians are prohibited from crossing the guide-way.

There are 108 berths for vehicles in the Morgantown/WVU PRT system, 22 each at the three middle stations, eight each at the end stations, and 10 and 16 respectively at the two maintenance facilities. During off-peak periods, many of the 71 vehicles will reside in the station berths. During periods of peak demand a large percentage of the fleet will be en-route between stations.

The three middle stations of the Morgantown/WVU PRT are of relatively complex design. Towers Station, which was constructed to meet significantly higher demand, has six switch points, six merge points, and six channels. Each channel or docking area has three or four vehicle berths.

The Engineering and Beechurst Stations are similar in design to the Towers Station. The layout differences reflect the differences in the expected volume and distribution of trips. Also, bypass lanes at the Engineering and Beechurst Stations are routed underneath the station. Engineering Station also encompasses one of the two maintenance facilities.

The physical dimensions of the middle stations are roughly 200 feet x 120 feet including platforms and channel guide-way. The size is dictated by the need to accommodate the various channel movement and expected capacity. These dimensions do not include deceleration/acceleration lanes of the guide-way.

Safety Systems

Morgantown/WVU PRT is designed for failsafe operation. A major component failure results in a graceful system stop, whereby all vehicles immediately slow down until they stop, and this stop occurs without vehicles crashing. Additional redundant systems include:

- Control/communications power uninterruptible power supply (UPS)
- Station lighting/surveillance power Standby generator
- Central computer Backup PC with automatic switchover
- Station computers Backup PCs with automatic switchover
- Central control system human monitors can override
- "Moving point" control system Collision Avoidance System Safe block system independently verifies safe distance between vehicles, using a second set of presence detectors.
- Brakes: Redundant 4 wheel disc brakes Tandem piston actuators w/ independent hydraulics per caliper
- Brakes: Parking brakes actuate when normal brake hydraulic pressure drops
- Presence detectors: Redundant presence detectors
- Successful switching detection: Vehicle validates guide-way's check
- Vehicle speed control: "High speed enable" guide-way magnets. Only in special guide-way segments can vehicles go fast.
- Tires: Second air chamber prevents punctures
- On-board vehicle control hardware, redundant hardware and safety checks (2)

Power Subsystem

A 23kV, three-phase, 60-Hertz power comes from the utility company and is distributed to the guide-way and stations. For the guide-way power rails, incoming power is converted to 575 VAC, three phase, delta power at three points on the guide-way. Passenger stations received 480/277 VAC, three-phase power for heating, lighting, etc.

B. London BAA/ULTra[ii]

ULTra

Urban Light Transport, *ULTra*, is a modern PRT system that became reality when it was implemented by the British Airport Authority (BAA) as a pilot network at Heathrow Airport to help shuttle passengers to and from a distant car parking lot to Airport Terminal 5.

With a nod to the history and success of other efforts in APM, GRT, and PRT design around the world, this BAA/ULTra mobility initiative proudly claims itself as the first traditional, super light-weight, Personal Rapid Transit designed to be commercialized for passenger use. It begins regular passenger service in late 2010

The ULTra system uses a fleet of low power, electrically driven vehicles on a dedicated guide-way. The operation of the system and movement of the vehicles on the network is managed by software and systems developed by Advance Transport Systems Ltd. (ATS), the maker of ULTra, which work to direct and distribute the independent vehicles on a network of direct routes and off-line stations to help provide non-stop travel.

The track is passive and switching is achieved by in-vehicle steering using an electronic guidance system. Stations have spacing similar to bus stops and the basic network form allows the guide-way to be one-way, providing important benefits in cost and visual intrusion.

ULTra can operate at-grade or elevated either within or external to buildings, offering the opportunity for more convenience to the passenger. Low loading footprint means that the system can be carried by conventional building structure with no need for structural strengthening. The vehicle has a small (16 foot (5 m)) turning radius and readily copes with grades of 20%, yet operating routes are limited to 10% to ensure passenger comfort.

Most reports commenting on ULTra's overall performance have suggested that the design, engineering and technology have indeed proven viable. Because the ULTra model mostly utilizes modern, yet mature, off-the-shelf, computing and information technologies from the automotive industry, they provide their product with a foundation of reliable systems and components. Some basic features of the ULTra PRT:

- Principal parameters - scale overhead or at-grade:
  - Width: 6.5 feet (2 m)

  Overhead
  - Depth: 1.5 feet (0.45 m)
  - Height above roadway: 18.7 feet (5.7 m)
  - Column spacing: 59 feet (18 m)

- Basic vehicle characteristics:
  - 4 - 6 seats
  - 1,000 lb (450 kg) payload
  - 25 mph (40 kph)

- Simplified analysis of theoretical capacity:
  - 50 seat bus every 5 minutes provides 600 seats/hour
  - 200 seat light-rail every 10 minutes provides 1200 seats/hour
  - 4 seat ULTra every 3 seconds provides 4800 seats/hour

After years of undergoing prototype testing, ATS currently examines and upgrades its product on two live test tracks: a simple track in Bristol and a more complex 0.6 mile (1 km) guide-way with overhead sections in Cardiff, Wales. According to site engineers, initial results have been very encouraging. Vehicle and track have been successfully integrated and over 1,000 circuits of the complex guide-way have been completed under fully automatic control.

Over $20M and 50 years of design effort has already gone into the ULTra system with considerably more invested in studies by ATS and other partners. According to recent estimates, the total cost of ULTra (vehicle, infrastructure and control system) works out to be between $7.2M and $11.9M per mile ($4.5M and $7.4M per km) of guide-way, and is about 3 times that cost to elevate it. At its most efficient scale, ATS estimates it would cost about $0.60 per trip to operate and maintain. The Heathrow pilot, however, is a smaller system, so will cost more per trip.

According to ATS, Ltd., the ULTra PRT system offers many overall benefits to the passenger:

- Immediate service: Passengers rarely need to wait for a vehicle, since the empty vehicle management system ensures that one will already be at the station. Simulations demonstrate that average waiting times, even in peak periods, average around 10 seconds.

- Non-stop travel: due to off-line stations, the journey is non stop from start to destination, anywhere on the network.

- No need to plan trips, consider schedules, or transfer between vehicles. Each vehicle is your own private cab to share with your friends and family. It is faster than other urban transport, typically by a factor of two or three. Although maximum speeds are modest (25 mph)*, non-stop service ensures short trip times.

- Travel is reliable, predictable and congestion free, affording passengers greater certainty in their journeys.

- Travel is safe: ULTra's target is safety levels at least as good as trains, approximately 10 times higher than automotive safety. Also, grade segregation implies less conflict with non-users and other modes.

- Accessibility: The system is available to all, including the young, the old, and those with disabilities.

In addition to the aforementioned user benefits, ULTra is stated to also provide major benefits to non-users of this automated form of urban transit, and to the community it operates in, as well:

- ULTra is energy efficient: Light, small, efficient vehicles traveling non-stop and only on demand result in significant energy savings. ULTra saves two-thirds of automotive energy requirements and is substantially more energy efficient than conventional public transport.

- ULTra meets Kyoto sustainability targets; providing the required 60% reduction in carbon emissions over the car now, rather than by the 2050 target date of the Kyoto agreement.

- ULTra is exceptionally quiet: measurements on the prototype vehicle running at 6m/s give 35dBA at 33 feet (10 m), around 30 dB less than cars. Lightweight vehicles permit ultra-light infrastructure and automated control allows high utilization. Small vehicles and guideways imply less land takings and less visual intrusion.

- ULTra reduces congestion: studies indicate significant modal shifts away from the car, freeing up both road capacity and parking space.

- Installation flexibility: small scale infrastructure may be readily integrated into buildings. ULTra provides new ways to reclaim areas of the city now given over to the automobile.
  Rapid installation minimizes cost and disruption.

History

ATS began developing the ULTra personal rapid transit system in 1995 in association with the University of Bristol. The PRT system emerged from systematic engineering analysis as the optimum solution to urban transport problems, for both the user and non-user of the transport system.


Cardiff Test Track

This research was led by Martin Lowson, Founder and former CEO of ATS. The company has been granted exclusive access to the commercial exploitation of the core Intellectual Property Rights (IPR) developed during that work and has since added significantly to its own IPR portfolio.

The company has completed the initial phases of prototype development and has undertaken successful passenger trials. The prototype system has consent from the UK Regulatory Authority (HM Rail Inspectorate) to carry the public, which represents a significant milestone. The Company has financed the high-risk initial phases of development from internal sources, from in-kind support by its major partners, and contract funding from the UK Government and potential customers. Total investment on the project to date from all sources is around $22.3M.

The company's testing facility was established in Cardiff, Wales in 2001. This facility contains all the features expected in a typical application, elevated sections, sections at-grade, various banked and un-banked curves, inclines and declines, merges and diverges and a station. The total length of the guide-way is just less than 0.62 miles (1km). In addition, the company has a research track on a six-acre site at Avonmouth Bristol.

The company's first 'A' vehicle started testing in May 2001, with initial testing at the companies Avonmouth site in June 2001. Testing continued on the Cardiff trials site through to June 2002.

This vehicle was then re-designated as an engineering test vehicle and has been used since that time for vehicle and control system development. A second 'A' vehicle was also made available for engineering test development in September 2002. The first 'B' vehicle, with a fully representative passenger compartment and automatic door system, was completed in February 2002 and has undergone extensive testing on the Cardiff site. Total test time is now over 1,000 hours in which the vehicles have traveled a distance of over 1,200 miles (2000 km).

In July 2003, the ATS developed navigation software and hardware was installed in the 'B' vehicle, and testing of this vehicle was carried out between that time and the end of September 2004. During this period, the 'B' vehicle was tested over 294 hours and traveled the equivalent of over 3,000 journeys with no equipment or operational failures being recorded.

Further vehicle system and debris testing has been carried out at Cardiff using the 'A' vehicle fitted with upgraded sensors and debris deflectors. This vehicle has also been used to develop the berthing techniques, equipment settings and improved algorithms for the control software. The track is in continuous use for development work and for demonstrations. Demonstration to a wide range of technical and customer teams has provided over 500 people with direct experience of the ULTra system, with unanimously positive response.

In addition to conducting on-going testing and demonstrating the pilot project at Heathrow, ULTra has also reported that The National Assembly of Wales has approved a bid by Cardiff County Council which will allow the council to support the first stage in implementing ULTra. This will enable the system to be operated between the Bute Street railway station and the Inner Harbor, Wales Millennium Centre, National Assembly of Wales and County Hall.

Possibly initiated as a public/private partnership project, it is envisaged that ULTra vehicles operating in the city center would connect to the docks area, a former industrial zone which is now an important business and residential center currently disconnected from the main city center; exhibiting a variety of transport difficulties.

Preliminary analysis of the project shows that ULTra would offer an effective solution for Cardiff, both directly and by complementing existing public transport. Based on the recent studies, the addition of a PRT network link in the Bay area would lead to 1,800,000 additional trips per year. The estimated cost of the completed 4.8 mile (7.7 km) network is $58M. All considered, Council members agree that Cardiff is well suited to the ULTra system because the City's regeneration has totally changed its transit needs; projecting that ULTra will ultimately serve 5 million trips per year.

Operations
ATS has been funded by a mixture of internal, private, funding and contract funding from both Government and prospective clients, together with significant in-kind support from major partners, such as the UK Department for Transport, the UK Department for Trade and Industry, NESTA (National Endowment for Science, Technology and the Arts), and the EC (European Commission).

Since inception, ATS has also been working closely alongside major partner engineering companies such as Altran, AMEC, Arup, Atos-Origin, Corus and Serco to coordinate the deployment of its system. This work has culminated in successful passenger trials for which Her Majesty's Rail Inspectorate has given consent for ULTra to carry passengers.

The effort exhibited by the management, technical expertise and commercial relationships developed by ATS over the years, many feel, has created a significant market opportunity for the company, and the industry. To date, ATS has risen in excess of $10M to fund the start-up phase of the business, and they currently point to worldwide interest in the ULTra system.

In 2005, British Airport Authority (BAA), the major airport operator in the UK, chose ULTra to provide better access to its terminals at Heathrow. The agreement between BAA and ATS includes an investment of $7.5M in the company in return for

25% of the equity. The latter stages of this investment are dependent on meeting various developmental milestones. The investment of $7.5M from BAA will allow ATS to complete the final production and commercialization phases of the Heathrow Airport project. The initial 3-year commercialization program will concentrate on the production of the vehicles, and the proving of the control systems.

According to Mike Clasper, CEO of BAA;

"Two key goals for BAA are the improvement of the local environment and better service quality for our passengers. BAA believes that PRT offers an opportunity to meet both of these goals. BAA are delighted to take the opportunity to invest in the ULTra PRT system which is clearly leading the world in this exciting and innovative technology."

Martin Lowson, Founder and CEO of Advanced Transport Systems (ATS), added;

"it is very satisfying both to be selected to supply the ULTra system for use at Heathrow and for the work of the ATS team on the ULTra system to now be supported by a major blue chip investor. We are working very well with the BAA team and look forward to carrying passengers on the ULTra system at Heathrow and in other applications around the world."

ATS has also stated that their mobility plan is not to replace buses and trains, which admittedly can operate on a far larger scale. ATS proclaims that ULTra is envisioned as an alternative to buses and trains only when a bus or a train is not the best solution to the transit problem; as in a denser setting with heavy pedestrian and other ground-level activity, such as city centers, campuses, or most other major population destinations.

To ATS, the notion is that ULTra will operate across a dense area, so people will use it rather than adding to street-level traffic, and so that the buses and trains could function efficiently as *entre*-city transit, complete with their own dedicated pathways; like LRT and BRT (Bus Rapid transit); further suggesting that a consequence to calmed traffic could be to allow roads and parking lots to be returned to other civic uses.

ULTra PRT

Vehicles

The vehicles are controlled autonomously. Once the vehicle has received its instructions from central control it will continue to its destination without any need for further input.

Extensive tests have been done on various forms of vehicle control. ATS has performed full scale system evaluations tests to examine control methods based on wire guidance, optical and radar sensing, embedded guide-way magnets and local sensors based on ultra-sonics or lasers. They found the last two of these approaches to be significantly more reliable and robust, so a combination of these is used in the final system.

Each pod is electrically powered with four rubber wheels. Battery pack weight is 64 kg and is only 8% of the vehicle's gross weight, compared to many electric cars which require up to 50% of gross weight for batteries. In testing, it has shown that it can recharge a 5 minute trip in 1 minute.

The vehicle is equipped with two permanent and two flip-down seats and has a level entry from the station, allowing plenty of barrier-free access for wheelchairs, shopping or pushchairs. Individual vehicles feature heating and air conditioning for hot or cold climates, as well.

ULTra vehicle - Principal parameters:

Gross weight	800 kg
Empty weight	400 kg
Maximum speed	40 km/h
Length	3.7m
Width	1.45 m
Height	1.6 m
Passengers	4
Payload (kg.)	450
Minimum Turn Radius to center-line of front track (m.)	5
Maximum Climb Angle (%)	20
Maximum Planned Climb Angle (%)	10
Maximum Planned Decline Angle (%)	6.25
Maximum Vehicle Speed on level (m/s.)	11

Modes
ULTra is a comparatively small-scale, light weight, modular system of transport that can expand and adapt to suit demands. By changing the number of vehicles, guide-ways and routes employed, different network characteristics will emerge accordingly. In addition, vehicles both act independently, or platoon like trains.

Performance
The idea for PRT, in general, is to achieve maximum efficiency by way of keeping constant vehicle speed, achieved by direct to destination travel, and by reducing vehicle spacing, or headways, on the guide-way. For ULTra PRT, a headway of 1 second is planned that will meet brick-wall stop criteria, which permits a typical passenger load during the peak hour of over 2,000 passengers per route kilometer, assuming an average 1.4 passenger per vehicle load.

Due to the stations being off line, the journey is non-stop, which reduces overall waiting time and journey time. When operating most efficiently, researchers claim that 4 out of 5 of users will have no waiting time at all, and 19 in 20 passengers will wait less than 1 minute, even at peak times.

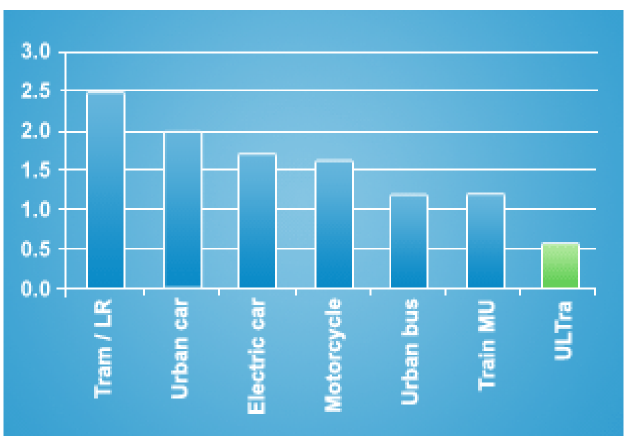
According to ATS research, ULTra has proven faster than other forms of urban transport by a factor of 2 or 3; nearly twice as fast as a car and about three times as quick as a bus. Traveling at an average of 25 mph, for example, the ULTra PRT vehicle makes a 1 mile journey in approximately 3 minutes. Comparatively, cars typically average less than 12 mph in cities, taking five or more minutes to travel that same mile.

ULTra readily handles grades of 20% although operating routes are limited to a maximum of 10% or less to ensure passenger comfort. It can operate outside on guide-ways, either elevated or adjacent to the road, and because its light loads, it can operate internally within buildings with no need for structural strengthening.

It is also designed to facilitate access for the disabled and/or those with need of easy entry. As mentioned above, the pods have level doors and can accommodate wheelchairs, as well as buggies/pushchairs and bicycles. All elevated stations would have a lift or will be housed in a building that provides one. Disability groups who have tested the system have told ATS that it is a very attractive to them as a means of transit.

Because ULTra is electrically powered, zero emissions are released at the point of use, while it also boasts significantly reduced energy usage overall; over 70% more efficient when compared with cars, rising to 90% in peak periods when cars are restricted by congestion. The average system energy usage is 0.55 MJ per passenger km. This can be compared with figures between 1.2 and 2.4 shown for conventional forms of transport in Table 5 shown below.

Table 5: Average System Energy Usage (MJ per passenger km)



This energy saving translates directly into reduced CO2 emissions. Documentation shows that ULTra meets the recommendation of the Royal Commission on Environmental Pollution, following the Intergovernmental Panel on Climate Change, that CO2 emission should be reduced by at least 60%. The RCEP target is set for 2050, and ULTra is able to exceed this target in the present decade - 35 years early.

ULTra also boasts an emission saving of a factor of 3 or 4 over current car or public transport, meeting Kyoto sustainability targets, providing the required 60% reduction in carbon emissions over the car today, rather than in 2050, which is the target date set by the Kyoto agreement.

Because the vehicles require considerably lower power than other forms of transport, ATS additionally notes a significant reduction in noise. Initial measurements indicate noise levels (35dBA) were indistinguishable against background noise. Noise levels for a car, at the same distance, would be about 65dBA; almost twice as loud.

It is worth noting that in the past four years of testing, there have been no documented failures of the system.

Guide-way

Like traditional PRT, ULTra runs on its own guide-way network with off-line stations. Typically, the pods are guided electronically with sensors embedded in the vehicle and the guide-way network is arranged in a series of loops, combined by merge/diverge section, serving key locations in the city.

The vehicles run at ground level or on elevated guide-ways in the form of a concrete trough, supported on a lightweight steel structure; columns are designed to be truck impact proof.

At ATS, considerable attention was given to minimizing visual intrusion during the design phase. Recently, they released the findings of a survey that stated that over 90% of people they questioned were very happy with the appearance of the track and less than 1% felt that it would be an unacceptable intrusion in their city.

ULTra Guide-way

Control Systems

Technically, the operating system is managed by software developed by ATS. It utilizes synchronous controls, similar to that used in air traffic control, and ensures that vehicles are only launched from their berth when it is known that there is a safe free route to their destination. This allows the central control system to respond to the passenger's request by allocating a vehicle for the journey and instructing the vehicle on the required path and precise timing for that journey.

Basically, the system manages fixed 'slots' for each vehicle at the prescribed headways and requires free routes to be identified from start to destination, including all merges before the launch of a trip from the station. Each slot is unique, ensuring there is no interaction between vehicles and includes empty vehicle management, which sends available vehicles to where they are needed, when needed, including to maintenance. ATS suggests that this reduces overall waiting times and ensures lower environmental impact due to not having to take unnecessary journeys.

The central control function, including development of effective empty vehicle-management algorithms, has been the subject of extensive simulations by ATS since the start of the project, and the functionality has been well developed and tested. Operating as a full scale network, real-time simulation results show that average waiting times will typically be under 15 seconds and the 95% of passengers will be served within a minute.

From a traveler's standpoint, this suggests that the passenger uses the system by going to the nearest station on the network, one of which would be equally distributed around the area and serve like modern bus stops. At each station the passenger can select their desired destination from one of a series of stand-by vehicles.

According to ATS, this is achieved via a smart card process that sends the selection of destination to central control which then provides movement instructions to the vehicle assigned to the job. The passenger boards the pre-programmed vehicle, which then automatically takes them to their desired destination, non-stop and by the best available route. At the destination, the passenger leaves the vehicle, which then may either wait there for the next fare or, alternatively, be redirected by central control to places with known vehicle demand.

Stations

The stations are distributed around the system, connected to the PRT network, like bus stops or cab lines. The stations are positioned where they are needed by commuters, regular passengers, residents, workers, students, visitors, shoppers, etc.; and in a well-populated urban environment, recommended spacing of a few hundred meters is typical.

ATS suggests that in nearly all applications of their ULTra system, the critical factor on overall system capacity is found to be the station's capacity and through-put, rather than that of the line, or guide-way. Major destinations, like hospitals, campuses, airports, business parks, malls, dense housing clusters, and entertainment districts are a natural fit for large-scale PRT stations. It is however, the small multi-berth stations, permitting a through-put of up to 500 vehicles per hour that need to be specially considered and well devised to fit the character of the area it serves.

Safety Systems
ATS has worked closely with Her Majesty's Rail Inspectorate (HMRI), the designated body of the UK Health and Safety Authority, to develop the ULTra safety system. This work resulted in HMRI issuing a 'letter of no objection' to the Concept Safety Case in August 2000, and has since provided their consent to the carriage of passengers on the ULTra system.

This HMRI certification followed on the heels of a full hazard analysis and failure modes and effect analysis undertaken in conjunction with industry safety specialists. The documentation resulting from these analyses provided the basis for the HMRI evaluation and consent. HMRI have also provided consent in principle to the approaches to be used in the initial Heathrow scheme which includes operation in tunnels.

ULTra is said to be fundamentally safe because it operates one-way on in its own designated and segregated guide-way. The maximum speed will be 25 mph, and within stations the maximum speed will be 5 mph. Added protection on the ULTra system is provided by an independent Automatic Vehicle Protection (AVP) system. This is based on a fixed block signaling system parallel to that used on railways. The fixed blocks are defined by inductive loops set into the guide-way which interact with sensing circuits on the vehicle.

Because ULTra is expected to operate to aircraft standards, ATS states that the possibility of breakdown is kept to a minimum. A monitoring system will diagnose weaknesses in a vehicle so it can be taken out of service to deal with before it breaks down. Breakdowns that do occur will be dealt with on a case-by-case basis. Because the vehicles are individually powered, the system is not brought to a halt by power failure. In the unlikely event that a vehicle does break down, a service vehicle will go and retrieve it immediately. The vehicle also has emergency exits and when no vehicles are traveling on the guide-way it is safe to walk on.

In addition, the vehicles' detection system will stop the pod automatically and alert control that there is something on the guide-way preventing the vehicle from proceeding. A person will be sent to retrieve the object immediately. There would also be extensive Closed Caption Television (CCTV) arranged over the whole system, the obstruction is likely to be noticed and removed before it even becomes an obstruction. Customer service staff would also be present throughout the system and able to retrieve any possible obstructions should they come across them before system control is alerted.

In addition, passengers have exclusive use of their vehicle and travel only with chosen companions. The system can be readily arranged to provide fully private vehicles and or fully private stations not accessible to other users. CCTV and the presence of customer service staff will enhance the security. Another design requirement for the system is to resist all possible effects from vandalism. The CCTV and staff providing customer service will be used to deter possible vandals and to minimize the possible effects.

In 2003, ATS undertook a series of passenger trials at the trials site, a track that reproduces all the features of a typical city application. The passengers undertook a representative journey, including use of the destination request panel, entering the vehicle, commencing (launching) the journey, completing an approximate 0.62 mile (1km) (journey that included inclines, declines, elevated track (18.7 foot (5.7m)) and various tight and sweeping corners. An independent survey concluded that all the passengers (100% of those participating) found the experience either satisfactory or very satisfactory.

Power Subsystem
ULTra is powered by a battery pack providing an average 2KW of motive power. This only adds 8% to the gross weight of the vehicle. Because the vehicle is light and travels only at low speed, power requirements are low. This means that battery power with opportunity recharging is practicable.

ULTra utilizes 0.55 MJ/passenger km, other forms of public transport use between 1.2 and 1.4 MJ/passenger km. According to ATS, solar power could be used via station or guide-way collectors. ATS is also watching a range of technologies, with the potential to offer cleaner energy, that are being developed, for example fuel cells. Once they are available in a practical form and can provide environmental benefits ULTra's modular approach will allow their adoption.

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[i] Morgantown People Mover – Updated Description. TRB 2005 Reviewing Committee: Circulation and Driverless Transit (AP040); http://en.wikipedia.org/wiki/Morgantown_Personal_Rapid_Transit

ii Engineering the ULTra System, Martin Lowson; www.alstd.co.uk

Appendix C: Planned or Proposed PRT Projects

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Planned or Proposed PRT Projects

Location	Status	System	Date	Notes
Masdar City, Abu Dhabi, UAE	Under Construction	2getthere	2011	Automobiles will be banned, the only powered transport will be PRT and intercity light-rail.
Bawadi, Dubai, UAE	Proposed	T.B.D.	NA	The overall development is 139 million sq. meters and 10 km in length.
Capital City, Dubai, UAE	Proposed	T.B.D.	NA	NA
Lulu Island, Dubai, UAE	Proposed	T.B.D.	NA	NA
Suncheon, South Korea	Planned	Vectus	2013	In September 2009, Vectus PRT, a Posco subsidiary, signed a MOU with the city of Sucheon to produce a 5 km system.
Cardiff, Wales, UK	Proposed	T.B.D.	NA	ULTra Test Track Complete. Evaluation ongoing.
Daventry, Northamptonshire, UK	Proposed	T.B.D.	NA	2008 Scoping Study - Network is envisioned to ultimately expand to 55.3 km (34.4 mi) of guide-way, and 500 vehicles. Daventry District Council placed the project on hold as of August 2009.
Ciampino, Italy	Proposed	T.B.D.	NA	Link City w/ Rome's 2nd Largest Airport. Routes Identified and Preferred option selected. PRT Simulation Conducted.
Almelo, Netherlands	Proposed	T.B.D.	NA	Connecting a Hospital, Railway and City Center. Routes Identified and Preferred option selected. PRT Simulation Conducted.
Over a dozen cities in Sweden	Proposed	T.B.D.	NA	Driven by KOMPASS, a constellation of cities in Sweden advancing PRT in more than a dozen cities as part of the country's commitment to liberate itself of fossil fuel dependency by 2020
Santa Cruz, California, USA	Proposed.	T.B.D.	NA	City Council has sent an RFQ and received responses from PRT suppliers.
San Jose, California, USA	Proposed	T.B.D	NA	Test Facility is being considered for SJ Airport. City sent an RFI and received 17 responses from PRT suppliers.
Fresno, California, USA	Proposed	T.B.D	NA	NA

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Appendix D: PRT System Availability and Status

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PRT System Availability and Status

The information in this Section has been compiled from Advanced Transit Association's report, "Personal Automated Transportation, Status and Potential of Personal Rapid Transit. 2003", and from the information available on each PRT/APM vendor's website (see URL's).

#	System	Location	Status	Seating Capacity per/ vehicle	Guide-way	Suspended/ Supported	Propulsion
1	**ULTra (ATS Ltd)**	UK	Completed System	4	Concrete	Supported	Rotary Motors
2	**Beamways**	Sweden	Simulation	4 - 6	Steel	Suspended	NA
3	**Innovia Bombardier**	Germany	Fully Operational	60-100	Concrete	Supported	Linear-Induction
4	**Mist-ER**	Poland	Partial Prototype	5	Steel	Suspended	Rotary Motors
5	**Skyweb Express Taxi2000**	USA	Partial Prototype	3	Steel	Supported	Linear-Induction
6	**UniModal SkyTran**	USA	Partial Prototype	2	Steel	Suspended	Mag-Lev
7	**Vectus PRT (POSCO)**	Korea	Operational	4	Steel	Supported	Linear-Induction
8	**2getthere PRT**	Netherlands	System under construction	6	Concrete	Supported	Rotary Motors
9	**Doppelmayr Cable Car**	Austria	Fully Operational	20+	Concrete	Supported	Cable Drive
10	**SkyCabs**	New Zealand	Simulation	8	Steel	Supported	Monorail
11	**AMT (American Maglev)**	USA	Full Prototype	20+	Concrete	Supported	Mag-Lev
12	**CyberTran**	USA	Full Prototype	6 - 20	Steel	Supported	Rotary Motors
13	**Austrans**	Austria	Full Prototype	9	Steel	Supported	Third Rail
14	**SkyCab**	Sweden	Simulation	4	Steel	Supported	Rotary Motors

1. Ultra (Advanced Transport Systems Ltd.); Bristol, United Kingdom, EU

For more detail, refer to **Appendix E: Case Studies**

Contact:

ULTra PRT

Advanced Transport Systems (ULTra)
Martin Lowson, CEO
Unit 5 Brunel Way
Thornbury, Bristol 3UR, UK
Phone: +011 (44-14) 5441-4700
Fax: +011 (44-14)n 5441-4770
Email: office@atsltd.co.uk
Web: www.alstd.co.uk

Salient Features:

ULTra uses numerous battery-driven, four-seat vehicles running over (not locked into) low-cost, low-impact guide-way networks with off-line stations providing PRT service. Maximum speed is 40km/hr. Controls are sensor-based. Two-second headways are envisioned in initial operations.

Status:

A 1km, 3-vehicle test track has operated in Cardiff since 2001. The first commercial deployment is scheduled to open at London Heathrow 's Terminal 5 in 2010. Safety approval is managed by the UK Rail Inspectorate. The British Airports Authority (now owned by Spanish Ferrovial) has purchased a 25 percent share of ATS, Ltd.

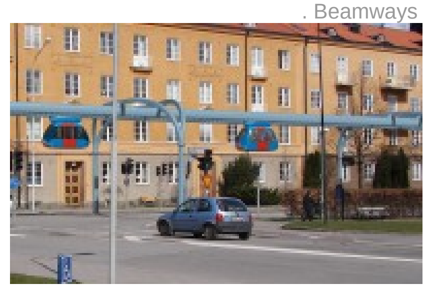
Urban Design Parameters:

Guide-way Envelope: w/ a pod sitting atop, the envelope is: 2.3m high and 2.1m wide.
Typical Footprint Requirement for a Guide-way Column Foundation: NA
Recommended Spacing between Columns: 18m. The vehicle payload is 500kg
Maximum Spacing between Columns: There is a standard 36.6m (120') spacing as well, with-out much overall cost penalty.
Minimum Radius of Curvature: 12.5m.
Maximum Recommended Slope: For passenger comfort, 10-degree rise, 6-degree decline.
Minimum Station Footprint: Vehicle length is 3.75m
Noise Level (decibels) of a Vehicle Passing: Less noise than a car.
Level of vibration at 40 and 80 km/hr: NA
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: Readily
Recent News: The guide-way phase of construction at Heathrow is over and integration of the system's software is next. A state of the art CCTV camera system is being installed along the whole 4.3-km route. Additionally, the Automatic Vehicle Protection (AVP) system has been installed in the guide-way. This safety system provides a fail-safe environment for operating multiple vehicles, similar to practices in the rail industry. Construction of stations also continues, including the installation of the vehicle-charging equipment, allowing vehicles to recharge their batteries whenever docked at a berth. Additionally, the vehicle storage and maintenance depot has been built and work commences on the internal build-out.

2. Beamways; Linkchoping, Sweden, EU

Contact:

. Beamways



Beamways
Bengt Gustafsson
Linkchoping, Sweden
Phone: +46-13 465-1085
Email: bengt.gustafsson@beamways.com
Website: www.beamways.com

Salient Features:

Traditional PRT configuration. Highly energy efficient. A suspended system featuring a low cost slender Bi-directional guide-way. Handles dense city settings. Weather proof.

Status:

Beamways is a new company currently in the early design phases, for instance guide-way structural integrity analysis. Work is also being performed in order to apply for patents for some unique ideas. Thus it is not possible to disclose all details at this time.

Urban Design Parameters:

Guide-way Envelope: 750mm high, 500mm wide
Typical Footprint Requirement for a Guide-way Column Foundation: < 500mm diameter
Recommended Spacing between Columns: 25 meters
Maximum Spacing between Columns: Longer spans are possible using suspension bridge methods, as the double-track guide-way easily lends itself to this. Cost has not been elaborated but should not be significant**.**
Minimum Radius of Curvature: Radius can be kept tight as the cars bank in curves. Minimum radius at low speed is 3 meters. Tracks themselves are not super-elevated (twisted) in curves.
Maximum Recommended Slope: 40 percent. The cars tilt back and forth in steep slopes to keep the floor level. This allows for at-grade stations if there is 10 meter available for ramps.
Minimum Station Footprint: A station at the guide-way level will have to have acceleration and deceleration ramps. The length of these depends on the traffic intensity on the main line. At a low intensity cars can start to decelerate on the main line which shortens the ramps. Beamways can save up to 50 percent on the ramp lengths by using the tilt function of the cars, at a given traffic intensity. This reduces the cost of stations and crossings significantly.
Noise Level (decibels) of a Vehicle Passing: This has not been calculated, but thanks to the drive wheels being enclosed in the guide-way the sound level should be very low
Level of vibration at 40 and 80 km/hr: The vibrations will be kept well below the ISO standard levels for causing nausea in passengers.
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: The only problem with entering buildings is that the upper side of the guide-way is almost 3 meters above floor level. There are no problems with noise, vibration or emissions. Our belief is that the type of buildings where stations are of interest will have at least 3 meters of ceiling clearance.
Recent News: Thanks to a recent capital injection from Syntrans AB, Beamways was recently incorporated and critical research and development work is moving forward. During the next two years Beamways will conduct studies to verify the viability of its basic concepts. This will be performed mostly using computer tools like CAD and FEM. Specialists in different areas will be engaged to participate in this work. Patents for the main ideas will also be obtained.

3. Innovia (Bombardier ART); Berlin, Germany, EU

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PO Box 220 Station A
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Phone: +1 (613) 384-3100
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Bombardier

Lebanon Church Road
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Phone: +1 (412) 655-5700
Fax: +1 (412) 655-5860

Salient Features:

Innovia is an innovative system with rubber-tired vehicles accommodating 60-100 passengers. It operates in 30 installations worldwide, often in simple back-and-forth shuttle mode. There are more elaborate corridors and loops with spurs as well. Perhaps most salient is the degree to which their comfortable and convenient service has become as commonplace as the reliability and safety of elevators.

Bombardier's ART's, first introduced at Tampa International Airport in 1971, continue to demonstrate high reliability, consistently delivering availability above 99 per cent. Its rubber-tired C-100 series and Innovia operate on a dedicated guide-way - at grade, in tunnels, elevated, or a combination to satisfy a variety of needs. The technology permits single-vehicle configuration or trains up to four cars, and easily accommodates peak periods during daily operations.

Status:

Innovia is the most familiar APM to many Americans, who have likely ridden one while flying through Atlanta, Denver, Dallas or San Francisco (or other) airports.

Innovia, first introduced in 1971, now boasts:
- 30 installations worldwide
- 300 vehicles placed into passenger service
- 3 billion passengers carried
- 100 million-vehicle miles accumulated
- half the world's top 30 airports use a Bombardier APM Product

Urban Design Parameters:

Guide-way Envelope: About 3 meters wide per direction, but there is variation from application to application. Bombardier will recommend unique products for each particular application.
Typical Footprint Requirement for a Guide-way Column Foundation: NA
Recommended Spacing between Columns: NA
Maximum Spacing between Columns: NA
Minimum Radius of Curvature: 22m
Maximum Recommended Slope: Up to 10 percent
Minimum Station Footprint: NA
Noise Level (decibels) of a Vehicle Passing: The vehicle-guide-way interface combined with new suspension and guidance elements, results in low noise impact
Level of vibration at 40 and 80 km/hr: NA
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: NA

Recent News: Using Bombardier's Advanced Rapid Transit (ART) technology, **SkyTrain** of Vancouver, Canada has become a flagship of driverless, urban transit systems. With the opening of the 12.6-mile "Millennium Line" to passenger service in August 2002, the 30 mile **SkyTrain** is the backbone of an impressive integrated land-sea-rail system and the longest driverless system in the world.
Since its inaugural launch into revenue service in 1986, **SkyTrain** has carried over 700 million passengers safely, reliably and cost effectively. Its fully automated, driverless technology features a unique steerable-axle suspension, linear-induction-motor propulsion, and a moving-block automatic train control system that enhances operational flexibility and system expandability.

The order of 60 vehicles, the second generation of the system's existing fleet, incorporates all the benefits of the original **SkyTrain** vehicle while significantly increasing the passenger-carrying capacity. Because of its higher performance standards, fewer trains are required to provide the same level of service, resulting in lower operating costs. Additional orders for new vehicles will be delivered in 2009.

4. Mist-ER Ltd; Poronin, Poland, EU


MIST-er

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Salient Features:

Mist-ER has the capability to expand its lines of infrastructure by adding stops, new lines, and intersections without modifying or touching any existing parts of the infrastructure. This capability is possible thanks to patented contact-less static switch (FROG).

Status:

A working 1:1 scale prototype, demonstrates operation of the vehicle and no-contact static switch.

Urban Design Parameters:

Guide-way Envelope: 800mm wide, 800mm high.
Typical Footprint Requirement for a Guide-way Column Foundation: Single-lane - 2m x 2m; Dual-lane – same.
Recommended Spacing between Columns: 25-30m
Maximum Spacing between Columns: 100m (3-4 times the standard spacing).
Minimum Radius of Curvature: 40m at 50 km/hr (with and without super-elevation); no plans to have 80 km/hr speeds.
Maximum Recommended Slope: 45 degrees.
Minimum Station Footprint: One-Way Station - 25 x 6m; Two-Way Station - 25 x 12m.
Noise Level (decibels) of a Vehicle Passing: Unknown, but < existing vehicles, like cars.
Level of vibration at 40 and 80 km/hr: Unknown, but < existing vehicle, like cars.
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: Easily because it is suspended.
Recent News: Actions to build the first commercial trial system in Opole, Poland are in progress.

5. Taxi 2000 Corp; Minnesota, USA

Taxi2000

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Salient Features:

Classic PRT with 4-passenger vehicles running in a slender beam at 70km/h at one-second headways. Propulsion is by linear induction motor. Sophisticated simulation and planning software has been developed.

Status:

Established by Dr. Ed Anderson in the early 1980s as a spin-off of his work at the University of Minnesota and work done by the California-based Aerospace Corp., Taxi 2000 is a privately held company. Taxi 2000 has well developed and demonstrated control systems, a prototype vehicle and guide-way section, and a tabletop network. To date, Skyweb Express' control system has been tested in several ways:

●The Alpha system demonstrates an actual working scale model of Skyweb Express, featuring its proprietary control system technology. This technology also operates TrakEdit, its propriety simulation software.

● Honeywell Corporation's Advanced Technologies Division examined the system and found no technical issues to prevent commercialization.

Urban Design Parameters:

Guide-way Envelope: With guide-way covers, the envelope is 0.9m wide and 1m high.
Typical Footprint Requirement for a Guide-way Column Foundation: Typical post is 25cm in diameter and 56cm in the ground. The type of soil and the seismic activity in the area installed will determine the depth of footing and final diameter.
Recommended Spacing between Columns: 28m
Maximum Spacing between Columns: A maximum spacing has not been determined. Engineering studies have indicated that a span of 55m would not collapse. So that if a post were removed due to an accident, there would not be a catastrophic failure of the guide-way in that area.
Minimum Radius of Curvature: 12.2m at 16km/hr; 64m at 56km/hr; 134m at 80km/hr.
Maximum Recommended Slope: The slope limitations are restricted only to those related to ride comfort. Because of the nature of the propulsion system slopes well outside passenger comfort can be safely achieved either in an uphill or downhill mode. Recommend a 10 percent slope based on passenger comfort.
Minimum Station Footprint: Vehicle length is 2.9m, minimum berth is 3.05m in length, thus station ramps require 11-50 length.
Noise Level (decibels) of a Vehicle Passing: Actual testing of vehicles at speed has not been accomplished, but we estimate that noise level will be comparable to other electric PRT systems or electric cars.
Level of vibration at 40 and 80 km/hr: Actual testing at speed has not been accomplished, but vibration levels should be low.
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: Because of the guide-ways small profile and light weight it can easily enter into a building or attach to a building.

Recent News: There was intense R&D in conjunction with Raytheon Corp. and the Chicago RTA with a full-scale test facility using rotary motors outside Boston in the 1990s, but commercialization was not achieved. Anderson separated from Taxi 2000 in 2005 after a new "product launch" occurred in 2003.

6. SkyTran (Unimodal Systems, LLC); California, USA

SkyTran

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Salient Features:

- ● Line capacity is calculated to be 14,400 people/hr /day.
- ● Personalized vehicles: Two person vehicle with climate control, communication, web access and music..
- ● Small portals: conveniently located every quarter mile. No massive stations or structures overwhelming the local environment.
- ● Maglev guide-way provides a non-contact bearing with ultra low maintenance. No wheels to wear out and replace.
- ● Standard utility poles: Universally available, stock item; Routine installation.
- ● Modular system: Translates into lower cost components and faster, less complex installations.

Status:

An active R&D effort is leading to the near-term construction of a Testing Facility in California. Also, in cooperation with a federally funded transport research institute at the U of Montana.

Urban Design Parameters:

Guide-way Envelope: NA
Typical Footprint Requirement for a Guide-way Column Foundation: NA
Recommended Spacing Between Columns: NA
Maximum Spacing between Columns: NA
Minimum Radius of Curvature: NA
Maximum Recommended Slope: NA
Minimum Station Footprint: NA
Noise Level (decibels) of a Vehicle Passing: NA
Level of vibration at 40 and 80 km/hr: NA
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: NA
Recent News: Marin County, CA supervisors recently voted to take the first steps toward the installation of a half-mile demonstration SkyTran system between the Marin Civic Center and its nearest SMART station, at no cost to the County.

7. VECTUS, LTD; Uppsala, Sweden & Seoul, Korea

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Vectus PRT

Salient Features:

Classic PRT with passive 4 / 6-passenger vehicles powered by reversible, in-guide-way, linear induction motors by Force Engineering and WGH of the U.K. Current work aims at 2.5 second headways and 45km/h commercial speed (60km/h maximum). Controls are by Noventus and civil work is done with Skanska.

Status:

Korean steel multinational, Posco, launched Vectus in 2002. A 1:10 model has operated in Korea since 2005. In 2006, the construction of a $40-million, 400-meter full-scale test facility in Uppsala, Sweden started and opened in fall of 2007. It has been under the supervision of the Swedish Rail Authority; passenger safety certification has been achieved in 2009. Also in 2009, a memorandum of understanding (MOU) was signed with the City of Sucheon, South Korea, to produce a 5km system.

Urban Design Parameters:

Guide-way Envelope: Vehicle size is 3.5m long x 1.5m wide x 2m high. The height required from load-bearing structure to the top of the running rail is less than 100 mm and the total height of the complete rail (running + guide) structure is less than 300mm. With a low vehicle height (adding less than 500 mm to the interior height), it is very easy to e.g. integrate stations inside buildings, etc. A tare weight of the vehicle of only around one ton adds further to the simplicity and flexibility of the track and its structural requirements.
Typical Footprint Requirement for a Guide-way Column Foundation: The guide-way concept is robust and simple, and can meet varying requirements and local conditions; it is equally suitable for elevated, ground or tunnel applications and also easily integrated into buildings. As a result, this allows the architect or system designer the freedom to develop the type of support most suitable for each application.
Recommended Spacing between Columns: The distance between the pillars and the support structure can be designed to suit both architectural requirements as well as specific pillar-distance requirements.
Maximum Spacing between Columns: NA
Minimum Radius of Curvature: 10 m (steered vehicle), 20 m (non-steered vehicle)
Maximum Recommended Slope: 10 percent
Minimum Station Footprint: Actual layout, number of berths, etc. will be decided on a station-by-station basis as required from estimated passenger flow. With the simple track design later modifications / extensions of stations can be built very easily.
Noise Level (decibels) of a Vehicle Passing: By using running wheels with very low friction on a hard running surface; e.g. steel, a very low running resistance is obtained both for straight and curved track. The emphasis in designing the vehicle has been to lower the wind resistance as much as possible, using aerodynamic simulations, to minimize the actual power required and noise made while maintaining the speed.
Level of vibration at 40 and 80 km/hr: NA
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: Integration of support structures into buildings can be easily done.
Recent News: The safety process of VECTUS PRT follows EU standard, "Railway applications – specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)". This is a standard that is well-implemented in the European Union and defines a process to support the identification of factors that influence the RAMS in railway systems.

Wherever applicable, the safety analysis has not only been done for the test track as currently built, but also with considerations for a larger, generic system. The overall safety targets have been verified for a sample large system by performing a Quantitative Risk Assessment (QRA).

The QRA included 78 different sensitivity calculations to verify the criticality of different input factors. For the larger system that was modeled, a passenger risk was quantified to 0.165 fatalities per billion person kilometers, which is well below the acceptance criterion of 0.3 fatalities per billion person kilometers, meaning that the VECTUS system's standards will be as high as or higher than the current performance of railway systems and metros in Western Europe in general.

A life-cycle cost model for a generic system has been developed. Parameters can be chosen for system size, operation hours, mileage, cost of labor, energy, et. It uses the RAM analysis combined with spare-part prices as input for all corrective maintenance; it has a maintenance plan with prices for consumables as a basis for the planned maintenance, and with an estimated maintenance organization, leading to a good quality estimate of the operational cost.

8. 2getthere; Utrecht, Netherlands, EU

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2Getthere

Salient Features:

2getthere markets and develops electronically guided vehicular systems. The lack of physical guidance ensures the capital and operational costs are minimized. The distributed architecture of the network controls ensures the system is flexible, robust and easy to extend.

2getthere also has a worldwide exclusive license for the application of FROG-technology and owns the rights to the CyberCab (PRT) and ParkShuttle (GRT) transit concepts.

Status:

2getthere's network and vehicle controls have a 24+ year development history in various demanding environments. The group transit system (GRT) has been realized at three locations, with the 2nd generation operational at an office park outside Rotterdam. A system is currently under construction in Masdar City, UAE and is slated for passenger service in late 2010.

Urban Design Parameters:

Guide-way Envelope: Width: 1.7m (PRT) or 2.4m (GRT).
Typical Footprint Requirement for a Guide-way Column Foundation: The vehicles can function in any street and does not need elevated rails.
Recommended Spacing between Columns: NA
Maximum Spacing between Columns: NA
Minimum Radius of Curvature: At 40km/hr and an accepted sideways acceleration of 1,5m/s2, the required radius is 80 meters. At 40km/hr and an accepted sideways acceleration of 1,0m/s2, the required radius is 120 meters. At 40km/hr and an accepted sideways acceleration of 0,6m/s2, the required radius is 200 meters.
Maximum Recommended Slope: 10 percent
Minimum Station Footprint: A custom design will be made based on the required capacity, number of berths and space available.
Noise Level (decibels) of a Vehicle Passing: @ 40km/hr and 10 meters, < 65dba
Level of vibration at 40 and 80 km/hr: NA
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: NA
Recent News: The 2getthere system has been recently selected as the preferred "green" transit network of Masdar City, the $22B mega-development in the United Arab Emirates. The city, which expects to be the first city entirely neutral in CO2 emissions in the world, will not have conventional cars, but will instead have 10 thousand electric pods. They will operate as taxis without drivers and the passenger will enter a screen and type in the destination chosen.

9. **DCC: Doppelmayr Cable Car; Wolfforth, Austria, EU**

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DCC Doppelmayr

Salient Features:

Cable propulsion technology and passive vehicles hold several key advantages. The elegant simplicity of the overall concept results in better performance, significantly lower operation and maintenance costs, greater flexibility in individual system design, rapid installations, superior passenger comfort , outstanding aesthetics, and greater environmental responsibility.

A team of more than 200 engineers use their collective expertise and an essential understanding of today's transportation needs to advance innovative application components for DCC, such as:

- track routing, track alignments/profiles
- steel/concrete guide-ways and steel structures
- civil engineering for stations
- vehicle bogie and body design
- computer aided calculation methods for transport applications (vehicle multi body simulations, structural born noise and vibration analysis, etc.)
- structural engineering
- system management and integration
- train control system power distribution design
- ropeway equipment design

Status:

Systems in Operation:

- Mandalay Bay, Las Vegas, USA: Public Opening: 04/1999.
- Birmingham, International Airport, UK: Public Opening: 03/2003;.
- Toronto, International Airport Shuttle, Canada: Public Opening: 06/2006;
- Mexico City, International Airport Shuttle, Mexico: Public Opening: 06/2007;

Systems in design and under construction & installation:

- Venice City APM System, Italy (under construction): Opening: 12/2008.
- MGM City Center APM, Las Vegas, USA (under construction): Opening: 07/2009.
- New Doha international Airport, Qatar (in design): Opening: 2010.

Urban Design Parameters:

Guide-way Envelope: Single steel guide-way: height 2m; width: 1.7m; Double steel guide-way: height 2m; width: 6.3m.
Typical Footprint Requirement for a Guide-way Column Foundation: Size depends greatly on the soil conditions, the column height, and the guide-way separation, but to provide some very approximate ranges for DCC’s system:

- Deep drilled shaft – could have single shaft 1.5 – 2m diameter for a single lane or short column. 3 to 4 meter diameter for a dual lane or tall column.
- Pile supported spread footing – 4 to 4.5m square for a single lane or short column; 5 to 6 meter square for a dual lane or tall column.
- Spread footing (very dependent on soil parameters) – 4 to 5m square for single lane or short column in good soils. 9m square or more for tall columns in weak soils.

Recommended Spacing between Columns: 25-30m.
Maximum Spacing between Columns: 60m / double guide-way costs for 60m span.
Minimum Radius of Curvature: 200m at 40 km/hr
Maximum Recommended Slope: 10 percent
Minimum Station Footprint: One-way station: loading/unloading one side: 6m wide x 24m to 30m long minimum; Two-way station: loading/unloading on the outside only: 18m wide x 30m long. Loading inside/unloading outside: 24m wide x 30m long.
Noise Level (decibels) of a Vehicle Passing: – 40 km/h: at 15m distance: 65 dBA
Level of vibration at 40 and 80 km/hr: DCC's rope guiding technology with the applied anti vibration elements provide sufficient elasticity and damping so no major vibrations are excited in the steel guide-way and in the adjacent structures. The service proven PERFORMAÒ haul rope type does not create exceptional noise above the ambient noise.
Furthermore, the guide-way is an elastic structure which works as an anti vibration element itself. DCC's experience with former projects shows that the forces created by the moving parts running over (vehicle) and running within the guide-way (rope and sheaves) are usually not the reason for vibrations, which can be felt on floors of adjacent structures.
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: No problem as long as the wall is designed for the load. The guide-way loading will likely be higher than a standard building wall can handle, so it will have to be a special wall design. No problem penetrating the wall, again as long as it is designed for it.
Recent News: Selected for its proven advantages and outstanding record, DCC is creating the Cabletren Bolivariano Project, a new people mover system for Venezuela's capital, Caracas. The system provides a critical link in an ambitious urban development project near Petare.

As part of Metro de Caracas Public Transportation System, the 1.43 miles (2.3 km) APM will feature four walk-through trains on a steel guide-way provide a system capacity of up to 3000 passengers per hour per direction. With a total of five stations, the system will include an interchange station for easy access to a local train, buses, and the new Metro Line 6.

In order to achieve the best possible passenger convenience, DCC introduced a pinched loop design. Operating up to four, fully synchronized trains, each on an independent rope with a dedicated drive and return unit, DCC's pinched loop technology reduces the interval between trains, or headway, to as little as four and a half minutes.

Scheduled to open in November 2011, DCC's custom designed APM will provide Caracas the connection it needs to complete development of an area just west of Petare, the second most populated region in South America.

10. SkyCabs; Auckland, New Zealand

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SkyCabs

Salient Features:

SkyCabs intends to construct a demonstration track to test the features and advantages of SkyCabs and confirm that expected construction costs can be achieved below US$20M/km.
Due to SkyCabs' small physical size, estimated operating cost, including depreciation allowance for the SkyCabs infrastructure and the cab fleet, is expected to be a fraction of metros, light-rail and other monorails. The Company believes that SkyCabs is the fiscally responsible public transport solution for the 21st century.

SkyCabs patented elevated two-way mono-beam passenger transport system forms an unobtrusive, less costly structure. Frequent, light, 8-seater cabs provide automated 'on-demand' service, halving travel time, and equaling four-lane motorway capacity above arterial roads.

Status:

SkyCabs is in the act of calculating the spec pricing for an initial demonstration network with three stations. Control system being detailed is ready for programming. Selection of major contractors is proceeding. Details/agreements for use of station land are initiated.

Urban Design Parameters:

Guide-way Envelope: Horizontal supporting structure envelope: 1.0m x 0.8m includes beam and tracks (Two-way); Including vehicles: For two-way system: 4.6m wide x 4.1m clear vertical height required on straight track. 5.3m height to allow passage of optional maintenance vehicle un-staffed, 5.7m min for carrying staff; Ruling gauge: 5.14m wide at bends.
Typical Footprint Requirement for a Guide-way Column Foundation: Single 1.5m diameter planter box for two-way line.
Recommended Spacing between Columns: 30m.
Maximum Spacing between Columns: Any span can be done. Increasing beam size does not affect tracks. Greater spans are determined by track and visual/aesthetic requirements and standard beam column castings.
Minimum Radius of Curvature: At 40 km/hr - 27m; At 80 km/hr - 102m, all seated.
Maximum Recommended Slope: 1 in 5 slope.
Minimum Station Footprint: Maximum normal line station serving two-way line able to take full line capacity when or if required; 50m x 16m. End of line single-sided station able to take full line capacity; 50m x 11.2m. Small stations not able to handle full line capacity and therefore not recommended; 35m x 9m single sided/or one-way line. 35m x 16m two-way line.
Noise Level (decibels) of a Vehicle Passing: At 10 meters distance - approximately 37-40dB; at 25 meters - approximately 31-33dB; at 50 meters - approximately 22-24dB.
Level of vibration at 40 and 80 km/hr: The NVH is expected to be similar to that of a premium brand automobile or better since suspension displacements will be smaller.
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: Easily done when designed into building floors; Penetration of building requires minimum 4m clear height x 4.6m width for two way track and structure.
Recent News: Seattle has recently worked through a bid process for building a two-way monorail line in which SkyCabs participated. SkyCabs withdrew at the end of the technical stage as the SMP Board was not prepared to entertain any changes to its specifications.

11. AMT (American Maglev Inc.); Georgia, USA

. AMT

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Salient Features:

AMT designs and deploys short-haul and midrange regional transportation systems using magnetic levitation, and featuring lightweight, aerospace-like vehicles and propulsion that has no moving parts over a half-inch magnetic field.

Status:

The AMT dream began in Atlanta during the early 1990s, when city leaders were contemplating how to handle the influx of visitors and the endless traffic congestion associated with upcoming Olympic Games. After years of successful levitation and propulsion testing in Florida, AMT was awarded its first project on the campus of Old Dominion University in Norfolk, Virginia in 2000.
In spring 2006, with support from investors, AMT proceeded with development, breaking ground on a new test site in Powder Springs, GA. By 2007, the product was fully operational with all speed, stability, automation and levitation testing surpassing all expectations.

Urban Design Parameters:

Guide-way Envelope: For a dual guide-way system, an envelope of 9 meters is required.
Typical Footprint Requirement for a Guide-way Column Foundation: A 1.5 meter diameter column is required for a dual guide-way system.
Recommended Spacing between Columns: Columns are spaced on 27 meter centers.
Maximum Spacing between Columns: Columns are preferred to be place on 27 meter centers due to economic reasons.
Minimum Radius of Curvature: For passenger comfort, gradients are limited to 3 percent and vertical curves to a minimum radius of 3,048 meters.
Maximum Recommended Slope: see above.
Minimum Station Footprint: AMT is very flexible when it comes to designing stations, working with the customer to meet any station requirements that they might have.
Noise Level (decibels) of a Vehicle Passing: NA
Level of vibration at 40 and 80 km/hr: NA
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: NA
Recent News: American Maglev is actively perusing several projects throughout the world. AMT is targeting four projects in particular: Los Angeles, CA; Fort Belvoir, VA; Orlando, FL and Abu Dhabi, UAE.

On May 12, 2008, AMT President & CEO Tony J. Morris delivered a presentation to Orange County, Florida. The proposed system would link Orlando International (MCO) airport to an Inter-modal Station and continue toward Downtown Orlando.

12. Cybertran International; California, USA

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Cybertran

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Salient Features:

The Cybertran guide-way is a double steel rail, like conventional rail, with the standard gauge of 56.5inches. Single axle propulsion bogies allow for tight turns with low wheel/rail wear and low noise. Six of the standard steel guide-way sections are field welded together to provide an operational unit 97m long, at the end of which temperature expansions are handled, emergency egress to the ground is provided, and sensor packages of system control are located.

A second type of guide-way section is a pre-stressed concrete section with the same dimensions as the steel section, but not rigidly connected in the field. This guide-way type is approximately 10 times heavier than the steel version and is used where aesthetics rule out simple steel sections.

The vehicle types have different seating arrangements, but only one body size is proposed. Seating ranges from 6 to 20. Multiple doors provide direct access to each seat or row of seats, with easy ADA accessibility. Propulsion units are designed to utilize a variety of motors and power transmission units, depending on speed range and power requirements of application. The long 11+ m length is partly due to aerodynamic cones on both ends.

Status:

The CyberTran team consists of 15 people at present in a range of employment with full time, part time, and on-call-as-needed personnel for tests and special development activities.
Their capabilities include systems engineering, planning with the NY Subway system, pertinent aspects of civil, structural and mechanical systems, electric power transmission and application, computer control and sensor development, radio transmission and control, and rail dynamics, as well as legal and financial control expertise.

In addition to the individual capabilities, working relationships have been established with a vehicle design company, two steel fabrication companies, an industrial architectural firm, and 2 major A&E firms with extensive experience in the design and construction of rail transit systems.

Approximately $5M has been spent to date in developing and testing CyberTran. This sum includes grants and funding from the U.S. Department of Energy and the U. S. Department of Transportation, private companies, equity from investors, personal funds expended by system developers, in-kind labor, *pro bono* evaluations, and donations of material and hardware. Ultimately, development and testing have been in progress for over 12 years.

The first CyberTran test vehicle was built and tested at the Idaho National Engineering and Environmental Laboratory (INEEL, U. S. Department of Energy R & D lab) in a year long program from September 1989 to September 1990. Testing and evaluation of the concept continued at the INEEL over the next 8 years with tests on self steering, automated control, vehicle manufacturing techniques, development of a second test vehicle, and evaluation of various guide-way designs, passenger handling issues, and safety systems.

The technology was moved to the former Alameda Naval Air Station in Alameda, California in 1998 where testing continued to demonstrate the guide-way switch and grade climbing ability of the vehicle. Testing continues to date with emphasis on the automated control system.

Urban Design Parameters:

Guide-way Envelope: 3m "sky print"
Typical Footprint Requirement for a Guide-way Column Foundation: 1.6x2.6x16m sections
Recommended Spacing between Columns: NA
Maximum Spacing between Columns: NA
Minimum Radius of Curvature: 16m
Maximum Recommended Slope: NA
Minimum Station Footprint: NA
Noise Level (decibels) of a Vehicle Passing: NA
Level of vibration at 40 and 80 km/hr: NA
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: NA
Recent News: Two test vehicles have been built and tested for a variety of operational parameters. Test tracks have been built in Idaho and California for specific tests and a new test track is being planned. Five different test series have been performed with the two test vehicles demonstrating:

- basic vehicle and track behavior,
- self steering of single axle propulsion units,
- operation of a vehicle actuated switch for rapid track turnouts,
- test of motor and power transmission options, and
- proof of vehicle grade climbing capability.

The #2 test vehicle is a prototype of the operational vehicle and has been used in the last 3 test series. A prototype of the elevated guide-way has been fabricated and was tested as part of Test Series 5. Design of the prefabricated elevated guide-way support column has been verified for use in high seismic zones such as the San Francisco Bay area.

The control system has been defined with computer testing and hardware simulation of the system demonstrated. System operation has been defined and computer simulation of passenger handling has been performed.

13. Austrans; North Ryde, Australia

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Austrans

Salient Features:

The Austrans concept uses vehicles the size of a minivan that provide seating for up to 9 passengers. Austrans vehicles will be operated on narrow gauge steel rails supported on dedicated guide-ways either elevated, at grade or underground. Ground-level off-line stations are envisioned for all guide-way configurations.

The essence of the concept lies in the combination of the better features of PRT and GRT with operation at substantially higher speeds than either. Service would be scheduled during peak- periods and would be demand-responsive (taxi-like) during the remaining hours of the day.

Austrans is also believed to be more economic than PRT because of its greater seating capacity. Its proponents argue that it would provide much more efficient loading of the guide-ways that would PRT. They also believe that rail technology offers significant advantages over rubber tires in terms of speed, stability and guide-way costs.

Rail also has some disadvantages (poor cornering, poor wheel/rail traction, operating noise) and the Austrans concept has been designed to overcome them. During the past five years, four patented concepts have been developed that will overcome these disadvantages, namely: (1) a self-steering bogie, (2) grip wheels, (3) a Z-rail section and (4) a high speed switch.

Status:

Development of the Austrans technology began in earnest in 1990 with an extensive review of existing work in the field of automated people movers and PRT systems. In 1993, Sinclair Knight Merz Pty Ltd, one of Australia's leading multi- disciplinary consulting firms, was commissioned to examine the feasibility of Austrans.

In July, 1998, work was initiated on a 0.5 km test track located in Sydney, Australia. The first track of its kind features inclined rails, and tight radius curves, including an 8 meter radius turn through 180 degrees. The track features two switches and 1 in 5 grades servicing an elevated section.

The high speed switch is mechanical in nature. Vehicles will be operated with a 2.5 second headway at 70 km/h. Off-line stations will be used to permit non-stop station-to-station service.

The first full-size self-steering bogie has been completed and used for testing purposes. It is now part of the P1 test vehicle which was installed in September 2000 and is the culmination of 16 months of additional design, manufacture and assembly work. The P1 vehicle incorporates the Austrans passenger module and includes its interior features. Key steering and rail-gripping features of Austrans have now been demonstrated. Vehicles will be powered via a third rail.

Urban Design Parameters:

Guide-way Envelope: 2.5 M
Typical Footprint Requirement for a Guide-way Column Foundation: NA
Recommended Spacing between Columns: NA
Maximum Spacing between Columns: NA
Minimum Radius of Curvature: 8 M
Maximum Recommended Slope: 20% maximum
Minimum Station Footprint: Station platforms are at the vehicle floor level with only a narrow gap between platform and vehicle and there is simple access to and egress from vehicles and will resemble a modern high-technology bus stop. It will comprise a single platform approximately 5 to 6 meters long to accommodate a single Austrans vehicle. The stop will contain the appropriate ticketing equipment and vehicle-call facilities.

The station can be extended into multi bay, on-line platforms for loading or unloaded up to five vehicles at the one time, off-line, with switches at either end of the station enabling stopping vehicles to leave and rejoin the through line. Off-line stations will permit the use of a combination of express and local services, or more complex on-demand control protocols where individual vehicles are directed to stop only at stations where they are to pick up or set down passengers.
Noise Level (decibels) of a Vehicle Passing: NA
Level of vibration at 40 and 80 km/hr: NA
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: Because the Austrans vehicles and guide-ways do not take up a lot of space, it is possible to fit economically into shopping centers, universities, airports, traditional public transport stations and other developments.
Recent News: Austrans is proposed as an entire public transport network for a small or medium sized city, or as a feeder into existing heavy-rail, light-rail and bus systems.

Austrans has markets for immediate commercial systems in the following areas:

- a medium flow, short haul, low speed shuttle (e.g. airport people mover)
- a feeder and distributor for a line haul system
- the principal internal transport mode in a contained area such as a university campus, hospital precinct, business park or shopping centre
- an alternative to light or heavy-rail for upgrading a service in an existing developed urban area from bus
- a moderate capacity line haul system (e.g. extension of an existing line haul service to a newly developed satellite new town)
- such systems have the potential to be upgraded, expanded and integrated into a citywide network.

14. SkyCab; Stockholm, Sweden, EU

. SkyCab

Contact:

SkyCab
Narvavägen 21
114 60 Stockholm, Sweden
Phone: +46 8-661 05 75
Fax: +46 8-667 77 10
E-mail: info@skycab.se

Salient Features:

Travelers approaching a SkyCab station push a button on an electronic card programmed with various destinations. By the time passengers reach the station, their SkyCab is waiting. SkyCab is programmed to automatically travel through a network to reach the destination.

Vehicles run on rubber tires with electric motors and on-board switches at speeds of up to 65km/hr. Standard SkyCabs seat 4 passengers and weigh under 1,000-kg. Special adjustable seating systems accommodate wheelchairs and packages.
Each SkyCab is equipped with a console panel, an information display and a mobile telephone to allow communication with the control center. Point synchronous (modified asynchronous) controls are used.

Status:

SkyCab is working in an international network together with 15 cities, several R&D institutions and a complete industrial group. The aim of the SkyCab project is to supplement buses, (local) trains and subway trains with a convenient, cost effective and environmental friendly PRT.

SkyCab is supported by: WWF as one of 12 foremost climate entrepreneurs in Sweden 2008; Banverket (Swedish Rail Administration), Confederation of Swedish Enterprise; Swedish Energy Agency; Nordic Council of Ministers´ NETS project, Power Circle, and Hofors.

Urban Design Parameters:

Guide-way Envelope: Guide-ways are typically 4-m above the ground
Typical Footprint Requirement for a Guide-way Column Foundation: NA
Recommended Spacing between Columns: NA
Maximum Spacing between Columns: NA
Minimum Radius of Curvature: 20M
Maximum Recommended Slope: 10 percent
Minimum Station Footprint: NA
Noise Level (decibels) of a Vehicle Passing: NA
Level of vibration at 40 and 80 km/hr: NA
Ease in Which Guide-ways can Attach To (and/or Penetrate Through) Building Walls: NA
Recent News: 4 major implementation study projects are underway:

● **Sigtuna:** Arlanda airport The Swedish City of Sigtuna has studied an 82km SkyCab system with 87 stations and 600 vehicles .Linköping.

● **Linköping:** The City of Linköping has studied a SkyCab system also with 82km track, 79 stations and 700 vehicles.

● **Stockholm:** Vetenskapsstaden in the City of Stockholm has studied a SkyCab-system for the university campus "Projekt". At time being the SkyCab project is in total about 200km track, 200 stations and 1.500 vehicles. A demonstration system - that can handle snow and ice - is in planning.

● **Malmö:** The City of Malmö has also studied a SkyCab-system

Appendix E: ASCE APM Standards

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APM Standards; Parts 1 - 4

- **Automated People Mover Standards, Part 1, ASCE 21-05.** *(UPDATED - replaces ASCE 21-96)*

  ANSI/ASCE/T&DI Standard 21-05 is Part 1 of the four-part Automated People Mover (APM) Standards, which establish the minimum requirements for safety and performance for APM systems. A comprehensive revision of ASCE Standard 21-96, this Standard includes minimum requirements for the design, construction, operation, and maintenance of APM systems.

- **Automated People Mover Standards, Part 2, ASCE 21.2-08**

  ANSI/ASCE/T&DI 21.2-08 constitutes Part 2 of a four part standard which aims to establish the minimum set of requirements necessary to achieve an acceptable level of safety and performance for an Automated People Mover (APM) system. Collectively this three-volume standard will assist the industry and public by expediting the approval and release process and facilitating the use of an APM system. Part 2 provides general information on vehicles and Propulsion and Braking Systems (PBS). Topics dedicated to vehicles include vehicle capacity and load, structural design, coupling, fire protection, and electrical systems. PBS topics include methodology, functions, component design and testing.

- **Automated People Mover Standards, Part 3, ASCE 21.3-08**

  ANSI/ASCE/T&DI 21.3-08 constitutes Part 3 of a four-part standard that aims to establish the minimum set of requirements necessary to achieve an acceptable level of safety and performance for an Automated People Mover (APM) system. Collectively this three-volume standard will assist the industry and public by expediting the approval and release process and facilitating the use of an APM system. Part 3 provides information on electrical equipment, stations, and guide-ways.

  Topics dedicated to electrical equipment include traction power substation equipment, wayside power-collection equipment, passenger station electrical equipment, and uninterruptible power supply. Topics relating to stations include disabled persons access requirements, platform edge protection, evacuation of misaligned trains, emergency lighting and ventilation, and fire protection. Guide-ways topics include blue light stations, intrusion protection and detection, emergency evacuation and access, fire protection, signage, emergency lighting and ventilation, emergency power supply, guide-way alignment, and structural criteria.

- **Automated People Mover Standards, Part 4, ANSI/ASCE/T&DI 21.4-08** *(NEW)*

  ANSI/ASCE/T&DI 21.4-08 is Part 4 of the four-part Automated People Mover (APM) Standards, which establishes the minimum set of requirements necessary to achieve an acceptable level of safety and performance for an APM system. This Standard covers the minimum set of requirements for maintaining automated people mover systems. Part 4 specifically provides information on Security, Emergency Preparedness, System Verification and Demonstration, Operations, Maintenance and Training, and Operational Monitoring. It also includes three informative annexes which offer to the user a series of options or instructions, but do not prescribe a specific course of action. These annexes are not a mandatory part of the Standard, and significant judgment is left to the user.

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Appendix F: Guide-way Scale Comparison

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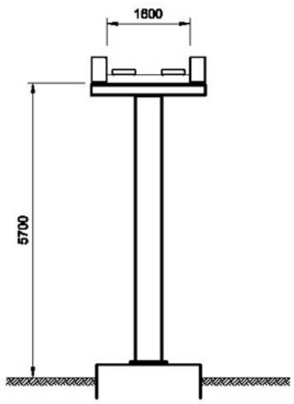
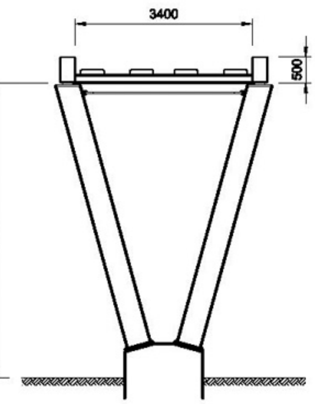
Scale Comparison of Rail-based Guide-way (in millimeters):

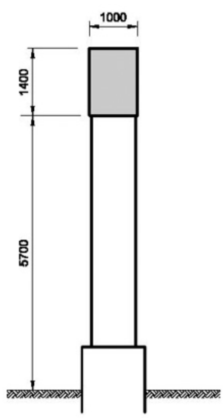
The PRT structure depicted is the ATS Ltd ULTra system as developed for its test site in Cardiff. Comparison is made with the Las Vegas monorail, the Sydney monorail, and the Kuala Lumpur LRT. (from: ASCE APM05 Special Sessions on PRT. Infrastructure Cost Comparisons for PRT and APM)



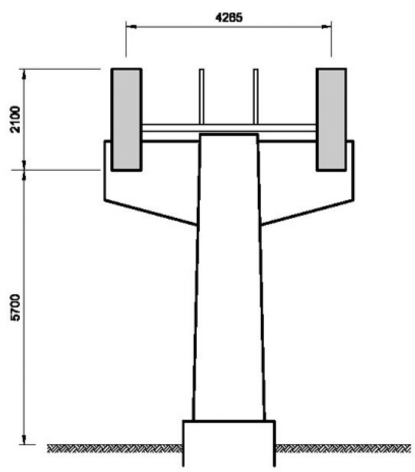
PRT SINGLE TRACK



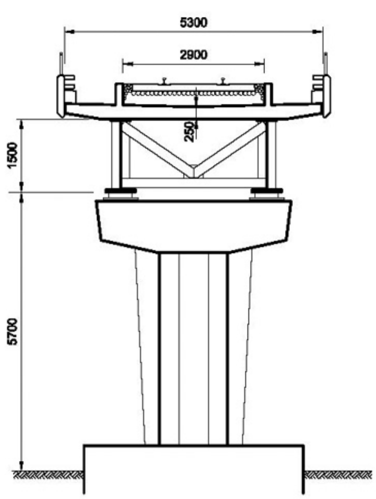
PRT DOUBLE TRACK



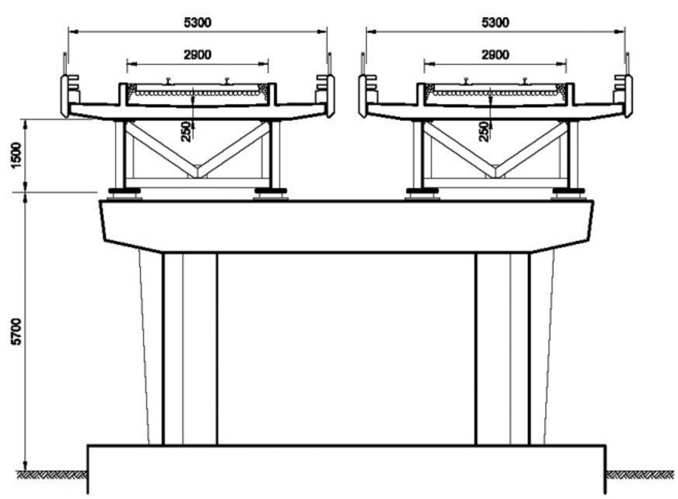
MONORAIL SINGLE TRACK



MONORAIL DOUBLE TRACK



LRT SINGLE TRACK



LRT DOUBLE TRACK

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Appendix G: Relevant Studies

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Summary of Relevant Studies

Tompkins County Comprehensive Plan – Planning for Our Future
Tompkins County Planning Department
December 2004/Amended December 2008

- On December 16, 2008, the Tompkins County Legislature approved an amendment to the County's Comprehensive Plan to address the issue of energy and greenhouse gas emissions. The amendment sets in motion a multi-faceted plan for the Tompkins County community to reduce energy demand, improve energy efficiency, make the transition to renewable sources of energy and reduce greenhouse gas emissions. Its goal is to reduce greenhouse gas emissions in the county by at least 2 percent of the 2008 level for each of the next 40 years, achieving at least an 80 percent reduction in greenhouse gas emissions by the year 2050.

- Growth based on New York Statistical Information System
  - 5,000 persons
  - 7,000-8,000 jobs
- Housing
  - Price of owning/renting housing in Tompkins County an issue (highest out of 7 surrounding Counties) leads to 'in-commuting'. The number of in-commuters from the six counties surrounding Tompkins in 2000 totaled 13,737. ***It is widely presumed that many who commute to Tompkins County would live here if they could afford to.***
- Transportation
  - The 2000 Census reported that 60 percent of the total commuters (and 69 percent of non-students) in the county drove alone to work, as compared to 75 percent nationwide. Fully 40 percent of commuters used alternative modes of transportation, compared to only 25 percent nationwide. Tompkins County also has higher percentages of residents using public transportation, carpooling, walking, and working at home than in New York State as a whole. Non-automobile use is higher in the City of Ithaca and other areas where development is compact.
  - 2000 Census data mode share (journey to work)
    - Drive alone = 60%
    - Walk = 17%
    - Carpool = 12%
    - Public Transportation = 5%
    - Work at home = 5%
    - Bicycle = 1%
  - Promote nodal development (plan)

Nodal development Impact on Transportation		
	Trend (suburban dev)	Plan (nodal dev)
Pedestrian (new households near community facility (1/2 mile))	3,207	4,657
Transit (new households near bus stop (1/4 mile))	1,798	3,095
Transit (new jobs near bus stop (1/4 mile))	5,524	7,317
Automotive (total miles traveled (pm commute))	263,714	258,942

- We can reduce automobile traffic and support alternative modes of transportation by encouraging compact development and by providing affordable housing near employment centers. Doing so will not only promote livable communities, but it will also keep overall transportation maintenance costs down.
  - Encourage the development of diverse communities that provide a mix of uses, a variety of employment options, social and recreational opportunities, and an assortment of amenities within walking distance of residential development.

- Improve transportation options for people who need access to employment, schools, shopping, health facilities, and community services.
- Nodal development – that is, development that is clustered in a population center – is a way to direct growth towards existing communities that are already served by viable infrastructure…. Denser development can also create opportunities for more transportation options, which lower vehicle miles traveled and ultimately improve regional air quality. Often existing neighborhoods can accommodate much of the growth that communities require through infill development, brownfields redevelopment, and the rehabilitation of existing buildings.
- Centers of Development
    - It is the policy of Tompkins County to:
        - Strengthen and enhance the City of Ithaca's downtown area as the urban center of the county.
        - ***Increase the amount and density of housing and business space in the central business districts throughout the county.***

Park and Ride Options for Tompkins County White Paper
Ithaca-Tompkins County Transportation Council for ITCTC Park & Ride Sub-Committee
August 2004

- Provides background on P&R facilities: types, operations, characteristics of successful locations
- Potential corridors
    - Route 13/366
    - Elmira Rd, Route 13 to south of city
    - Trumansburg Road – Route 96
    - Slaterville Road – Route 79
    - North Triphammer Road – Pyramid Mall
    - Eastshore Drive – Route 34
    - Danby Road – Route 96B

Northeast Subarea Transportation Study Transit Planning Project Report (NTTP)
Multisystems/Creighton Manning/CAST of Cornell University
ITCTC
February 2003

- Northeast Subarea Transportation Study – purpose to determine what it would take to shift 3%, 5% or 10% of person-trips in cars to transit
- Conducted telephone survey of 500 households
- Recommends transit hub at Pyramid Mall
- Many potential service route changes
  - Route 11 – provide one-seat ride from Ithaca College to Pyramid & provide service to both Longview and Towers every trip
  - 4 different express services
    - A – Pyramid to Cornell
    - B – Pyramid to Downtown
    - C – Cornell to P&R at Bethel Grove Church
    - C – Downtown to P&R at Bethel Grove Church
- Cornell
  - 1,800 employees receive countywide transit pass (1.4 million trips taken)
  - All faculty/staff ride free on weekdays in urban zone (1D)
  - Students option – Omniride – countywide used by 6,100 students
  - Free blue-light service on Routes 91, 92 & 93 after 6pm
  - B-lot parkers get PlusPass (similar to Omniride)
- Ithaca College
  - Drive alone share = 83%
  - 800,000 SF growth in 10 years
    - College Circle Apartments expanded to house 350 more students
    - Relocation of parking to periphery
- Excluding Cornell, transit mode share = 3-4%

2025 Long Range Transportation Plan
Ithaca-Tompkins County Transportation Council
December 2004

- Vision Statements
  - Community Issues and Transportation
    - Goal I: Develop a transportation system that enhances the quality of life for Tompkins County residents and visitors.
    - Goal II: Protect and enhance the economic vitality of Tompkins County.
  - Environmental Issues
    - Goal I: Ensure that the transportation initiatives address air emissions issues in a comprehensive manner with the goal of improving or maintaining air quality.
    - Goal II: Encourage and implement the development of a transportation system, which uses energy efficiently and minimizes transportation related traditional fossil fuel consumption.
    - Goal III: Limit the negative impacts or disruptions to the natural, scenic, or cultural environment.
  - Infrastructure Issues
    - Goal I: Improve the planning and design of local infrastructure.
    - Goal II: Identify existing & future infrastructure needs.
  - Mobility Issues
    - Goal I: Develop a transportation system that is accessible to all users.
    - Goal II: Promote and use design innovations to achieve system diversification and efficient intermodal linkages.
    - Goal III: Achieve and maintain the efficient operation of the transportation system in Tompkins County.
    - Goal III: Enhance the movement of freight in the Ithaca-Tompkins County metropolitan area.
  - Pedestrian Issues
    - Goal I: Create a safe and efficient network for pedestrian travel.
    - Goal II: Urge pedestrian oriented land use development.
    - Goal III: Promote walking as a viable mode of transportation.
  - Public Transportation Issues

- Goal I: Identify existing and emerging markets and provide a package of public transportation services capable of capturing those markets.
    - Goal II: Operate safe, comfortable, accessible, environmentally friendly, transit vehicles.
    - Goal III: Exceed customer expectations for transit system convenience.
    - Goal IV: Develop infrastructure resources to support public transportation.
    - Goal V: Promote comprehensive public transportation services to improve quality of life, to encourage economic revitalization.
- The principles and policies of the Comprehensive Plan recommend future development that emphasizes nodal development patterns, where development, increased densities and mixed uses are encouraged in existing urban areas, villages and other currently developed areas. This approach is supported by the goals and objectives found in the LRTP. A shift to nodal, mixed use development patterns is expected to result in, improved conditions for the provision of transit and for shifting a greater number of trips to walking and bicycling.
- The comparison between the Plan-Based and the Trend-Based scenarios showed that the allocation and distribution of growth could have an effect on traffic. Although a 2% reduction in VMT and VHT may not seem like much, it is important to remember that it is only reflective of the one-hour afternoon peak hour of traffic. If future land use development patterns apply the vision of the Comprehensive Plan and the LRTP reductions in traffic can be expected to extend through the 24-hour period. The cumulative differential between the Trend-Based and the Plan-Based scenarios then becomes significant when measured over a period of time. For example, looking at the peak-hour VMTs over a one year period would result in 1.1 million less vehicle miles traveled in the Plan-Based than in the Trend-Based scenario. The benefits of this difference translate directly into reduced congestion and all its secondary positive effects, in addition to lower emissions of smog inducing gases and greenhouse gases and reduced energy consumption.
- TCAT data indicate that current ridership is 2.8 million passengers per year, approximately 11,000 per day.
- PLANNING EFFORTS

I. Land Use Plan and Policies:

1. Review of Local Development Regulations
2. Develop Traditional/Physical Land Use Plans

IV. Transportation Infrastructure

5. Transit Infrastructure

III. Transit Programs

2. Enhanced Downtown Ithaca Transit Facilities (City Center Project) - This is an ongoing project. TCAT is reassessing and enhancing their network of transit stops around downtown Ithaca.

5. Linking Collegetown and Downtown Ithaca - Feasibility Study

- Climate Change and Energy Position Statement - As an important contributor to planning efforts for the Ithaca Urbanized Area and Tompkins County, the ITCTC's role is one of cooperation, support and serving as a catalyst for transportation programs and projects. In such a role, the ITCTC will help maintain an ethic and awareness that prioritizes climate change and energy security in transportation policy and in other policies that directly and indirectly affect the way our residents travel. The ITCTC will also work with local leadership to generate community involvement in planning for a more sustainable future.

  In particular the ITCTC will work through its required core planning documents, the 20-year Long-Range Transportation Plan (LRTP), the Transportation Improvement Program (TIP) and the annual Unified Planning Work Program (UPWP), to promote goals that help address the challenges of climate change and energy descent. The LRTP embraces a the concept of Sustainable Accessibility, which reflects the community's vision of transportation as a truly integrated multimodal system that recognizes the combined role of proximity of land uses, connectivity, mobility and its interaction with our environment and our quality of life.
- Vision: Sustainable Accessibility
  - The 2030 vision for the future of the Tompkins County transportation system embraces the concept of Sustainable Accessibility. This concept expands our vision, transforming transportation systems into mobility networks that are responsive to pedestrians, bicyclist, transit, rail, freight, and motorists while meeting the vehicular congestion, energy and environmental concerns that are now an impending crisis. Sustainable Accessibility can be defined as the ability to get to a destination or complete a task in an efficient, convenient, and reliable way, while using technologies and services that minimize environmental impacts, promote economic vitality and ensure equity in the provision of transportation to the community.
  - ***The challenge of Sustainable Accessibility is to identify opportunities and begin to integrate transportation modes (i.e. transit, bikes, walking, cars, car sharing, van pool, trucks, rail, etc.) so they address personal transportation and commercial needs in ways that will enhance our quality of life and promote sustainable growth in Tompkins County.*** Sustainable accessibility will serve as the organizing principle to develop clear transportation goals and objectives that respond to community needs and are implementable within an acceptable time frame. The vision of sustainability will require insight into the social structure as well as the infrastructure of the community so that the enhancements to the transportation system service all communities equitably.
  - ***The vision of Sustainable Accessibility will integrate transportation with land use planning for nodal development to promote land use patterns that reduce dependency in the automobile as a sole source of transportation. With sustainable accessibility at its core the transportation network will integrate multiple modes of transportation so that traveling by transit, bike, car share, car pool, etc. becomes as attractive, convenient and cost effective as private car ownership and use were in the second half of the 20th century.*** By bringing all modes to bear, the transportation system becomes more efficient and more resilient. A vision of Sustainable Accessibility will also embrace new transportation options and technologies, which will emerge as more investments are made to address the challenges of energy descent and climate change.
- Vision Statement Goals and Objectives
  - Overarching goals that pervade all other goals and objectives:
    • To improve the safety of the transportation system.
    • To enhance coordination between transportation providers to the benefit and convenience of users.
    • To minimize negative environmental impacts of transportation
    • To reduce vehicle miles of travel and vehicular emissions
    • To reduce fossil fuel energy dependency
  - INTEGRATION - To develop an integrated transportation system for Tompkins County that is seamless, multimodal and coordinated to achieve greater operational efficiencies and increase the safety and convenience of users.
  - MOBILITY - To promote implementation of transportation services, programs and projects that enhance mobility.
  - PROXIMITY - To achieve land development patterns that enable the efficient provision of multimodal transportation services.
  - CONNECTIVITY - To maintain and improve transportation networks to enhance safety, multimodal and intermodal connectivity and facilitate the movement of people and goods.
  - QUALITY OF LIFE - Develop a transportation system that sustains and enhances the quality of life for Tompkins County residents and visitors.

    - ENVIRONMENT - To work progressively towards a transportation system that will have zero-net negative impact on the environment.
- When combined into a category termed by some as "alternative modes of transportation", transit, pedestrian and bicycle trips account for the following percentages of work trips: 8% for the U.S., 33% for New York State, and 25% for Tompkins County. The figures for New York State are skewed by the disproportionally large participation in public transportation in New York City. Regardless, the 25% figure for Tompkins County represents a significant number of trips that are taking place with minimal impact on automobile traffic congestion levels.
- The primary local public transit operator is Tompkins Consolidated Area Transit, Inc. (TCAT) which was reorganized by Cornell University, City of Ithaca and Tompkins County in 2005. TCAT operates 36 bus routes serving all of Tompkins County and portions of Tioga and Schulyer Counties. TCAT ridership exceeded 3 million passengers every year since 2005 (approx. 3.3 million in 2008).
- Parking and Circulation
    - ***The City of Ithaca and Cornell University include the principal employment centers in the Tompkins County.***
    - ***In urban areas seeking increased densities in order to stimulate their local economies and the vibrancy of the community, parking requirements may need to be reconsidered in order to allow more land to be dedicated to productive uses (residential, office, commercial) instead of parking.*** The City of Ithaca can consider offering access to transit and car share as 'credits' to reduced parking requirements. The ITCTC supports the City of Ithaca's efforts to consider and debate these issues in the Collegetown Plan. The ITCTC will work closely with the City of Ithaca, Cornell Transportation Services, TCAT and other community partners in studying and developing parking management strategies and plans.
- Transportation Demand Management
    - Public transportation plays a key role within travel demand management programs. The ITCTC supports efforts that will make public transportation easier to use by overcoming some of its associated penalties (time, inconvenience, etc.). Past studies by the ITCTC and TCAT propose strategies and recommendations aimed at enhancing transit service in Tompkins County. The ITCTC will work with TCAT and other MPO partners to facilitate implementation of those recommendations that show greatest promise. In addition the ITCTC will work cooperatively with other agencies to attract more commute riders to public transportation. This can be achieved through a ***series of strategies aimed at expanding and enhancing commuting services including: establishing a coordinated park and ride program for the urbanized area, continued monitoring of bus route operational efficiencies, discount programs and other pricing incentives to commuters, and exploring programs to provide guaranteed rides back.***
- ***Segments of NYS Routes 13, 96 and 79, through the City of Ithaca, are currently at (v/c> or =.9) or approaching (v/c.8-.9) congestion.***

Tompkins County/Cornell Employee Commuter Survey
Cornell University Survey Research Institute
Phases 1 & 2 Cumulative Findings
February 2006

- Among non-Tompkins County employees:
    - 54% lived outside Tompkins County because of housing costs
    - 30% would consider moving to Tompkins County if housing was more affordable
    - ***25% would consider moving to Tompkins County if housing was more available***
    - ***80% would want a single-family home if they moved to Tompkins County***
    - ***46% would want to live in a traditional village***
- Reasons for not taking transit
    - Personal
        - 44% needed car for errands
        - 35% liked independence
        - 25% needed car for business
    - Service
        - 27% bus not available when needed
        - 21% bus takes too much time
- If commuter's concerns were addressed
    - ***27% would take transit most of the time***
    - ***40% would take transit some of the time***
- Importance of (top 3) issues that would encourage use of Park and Ride
    - 76% reaching work on time

- 51% location of parking
- ***49% express service***
- 35% cost difference

2008 Cornell Master Plan for the Ithaca Campus
Urban Strategies, Inc., Polshek Partnership Architects, Stantec, New England Engineering
March 2008

- Committed to keeping student body constant – expansion on campus to address present needs
- Want to optimize transit ridership through optimizing network and simplifying service
  - Create transit hubs on campus
  - ***Develop a campus circulator***
  - ***Provide later service***

transportation-focused Generic Environmental Impact Statement (t-GEIS)/
Transportation Impact Mitigation Strategies/Supplemental Documents
Trowbridge & Wolf Landscape Architects, LLP/Martin/Alexiou/Bryson, PLLC
Cornell University
June 2008

- The transportation study reveals the following existing transportation conditions:
  • Cornell employees commute by single-occupancy vehicles at greater rates than Cornell students do.
  • Employee commuting tends to occur in the morning and evening peak periods, when volumes on roadways are already highest.
  • 30 percent of employees who currently drive alone said they would walk if they lived closer.
  • 40 percent of employees who currently drive alone said they would cycle more under the right conditions.
  • ***80 percent of employees who currently drive alone said they would consider using the bus with schedule or route improvements.***
  • About one-third of employees who responded to the travel survey said they would consider vanpooling.
  • Nearly half of employees who responded to the travel survey indicated that one or more improvements could encourage them to carpool.
  • About 9 percent of Cornell employees, 31 percent of graduate students, and 70 percent of undergraduate students currently walk to campus.
  • Only 3 percent of Cornell employees and 4 percent of graduate students currently bike to campus
  • There are opportunities for improvement to transit, such as extended hours of evening operation, more frequent service, and emergency ride home programs.
  • There is room for improvement of Cornell's transportation management programs.
- Approximately one in three faculty and staff ("employees") respondents report living outside Tompkins County while more than half report living more than 5 miles from campus. Almost none of the employee respondents live on the campus. Essentially all of the student respondents live within the county and 84 percent of graduate student respondents and 97 percent of undergraduate respondents live within 5 miles of the campus. Among graduate student respondents, some 16 percent report living on or immediately adjacent to campus in university-affiliated housing, while nearly 60 percent of undergraduate respondents report living there.
- Frequency and Time of Travel
  - 95 percent of employee respondents make at least one trip to campus during the day (with 14 percent making multiple trips) just 14 percent come to campus after 7 p.m.
  - Nearly all graduate student respondents (98 percent) make at least one trip, nearly 30 percent make two or more trips to campus on a typical day. Nearly half of all graduate student respondents (49 percent) return to campus one or more times during the evening.
  - Undergraduate student respondents' travel patterns are relatively similar to those of graduate student respondents: 98 percent make at least one trip during the day and 57 percent make multiple trips; 61 percent report traveling to campus at least once during the evening.
  - ***Noticeable mode shifts for evening travel as more people drive to campus.***
    - Employee – 80%
    - Graduate Students – 60%
    - Undergraduate Students – 35%
- ***Student reasons for owning a car – shopping and personal errands.***
- The primary improvement required to get those employee respondents who currently drive alone to switch to the bus is simply access to the bus (a stop close to their home). Second to that – and most frequently cited overall – is an increase in the frequency of the service. ***The demand for an increase in frequency is representative of the primary reasons cited for not taking the bus to work: the time it takes and the bus schedule not meeting their needs.***

Cornell University—Ithaca
Greenhouse Gas (GHG) Emissions Inventory
Fiscal Year 2008

Mode of Travel

	Drive Alone	Carpool & Drop Off	Vanpool	Bus	Private Shuttle	Bike	Walk	Other
Employees	56%	17%	0%	14%	0%	3%	9%	1%
Undergraduates	5%	3%	0%	15%	5%	1%	71%	0%
Grad & Prof'l	19%	6%	0%	38%	2%	4%	31%	1%

Collegetown Vision Statement/Urban Plan/Conceptual Design Guidelines
Collegetown Vision Task Force & City of Ithaca Department of Planning & Development
June 2007

- These documents focus on the area bounded by Mitchell Street/East State Street on the south, Cascadilla Creek on the north, Eddy Street on the west and Linden Avenue/Summit Avenue in the east.
- Connection between Cornell & downtown
- Goal is to create a diverse, commercially viable, dense, mixed-use community characterized by notable urban design, a predominantly student population, high quality architecture, vibrant public spaces, and pedestrian amenities.
- ***A convenient public transportation system connecting Collegetown and the surrounding neighborhoods to the larger Ithaca community is a strategy for reducing car traffic in Collegetown and enhancing the environment for pedestrians.***
- The carshare vehicle in Collegetown is one of its most utilized vehicles
- Increase number of free or subsidized transit passes along with other TDM measures

The Downtown Ithaca 2020 Strategic Plan, Draft 3.1
The Downtown Ithaca Alliance
February 2010

Strategic Plan Executive Highlights

1. Downtown's strength lies in its diversity of people. Downtown will be successful if it is able to fully actualize this commitment to diversity. There should be an ongoing commitment to diversity in downtown programs, policies, and actions that permeate every sector and every activity.
2. Downtown Ithaca must maintain its regional share of retail activity. To accomplish this, downtown will add 90,000 square feet of new retail during the period 2010 – 2020.
3. Downtown Ithaca must maintain its regional share of office space. To accomplish this, downtown will add another 200,000 square feet of new office space during the period 2010 -2020.
4. Downtown Ithaca is one of the primary centers for new housing development in both the City and the region. During the period 2010 – 2020 downtown will seek to add between 300-500 units of urban housing.
5. Seek to fully utilize Six Mile Creek by developing a trail into the gorge and making downtown the hub for trail activity.
6. Continue a program of new in-fill development and redevelopment of current low-density sites. Based on a volumetric study conducted in 2008/9, it is projected that during the period 2010 -2020 the downtown could potentially attract up to 10 new projects totaling at least 500,000 square feet of space and a projected investment of at about $100 million.
7. During the period 2010 – 2020, downtown Ithaca will look to meet its new development parking needs, first and foremost, through attention to walking, bicycling, and other alternative transportation modes.
8. This plan relies on a dense urban core tempered with a pedestrian friendly street-level environment.
9. This strategic plan calls for the recruitment and placement of at least ten (10) new pedestrian foot traffic generating projects to be located in downtown during the period 2010 -2020.

10. This strategic plan calls for a careful review and possible realignment of downtown parking management and Commons maintenance.
11. This plan proposes a program to undertake opportunistic land banking of key downtown properties.
12. This strategic plan calls for amendments to current downtown zoning to improve the viability of key downtown parcels for future in-fill and redevelopment activity.
13. This strategic plan calls for the Downtown Ithaca Alliance to work collaboratively with other commercial districts on issues and programs of mutual interest.
14. This plan calls for the creation of new and improved transportation links between downtown and Cornell University/Collegetown as well as Ithaca College, including possible enhanced shuttle service and possible fixed rail service.
15. This plan calls for the review and improvement of financial tax abatement incentives to assist downtown projects to meet and fill funding gaps.
16. This plan calls for the creation of additional meeting and conference space to help attract small and mid-sized conferences to the community, perhaps in conjunction with the State Theater.
17. This plan calls for the addition of a fourth hotel project during the period 2010 - 2020.
18. This plan calls for the City and County to explore the concept of a new joint City of Ithaca/ Tompkins County Administration building to be located in downtown.
19. This strategic plan calls for the community to work closely with the institutions of higher education to partner with future downtown projects during the period 2010 – 2020.
20. This plans calls for the community to collaborate on the creation of a downtown teen activity center.
21. This plan suggests exploring the modification of the 100 West State and 300 East State blocks for inclusion into the pedestrian mall and/or periodic temporary closure to accommodate special events and community activities.

Downtown Ithaca: Big Ideas

i. Mixed Uses: Downtown must have mixed-use projects and mixed-use streets.
ii. A Dense Urban Core: Downtown density and downtown success are inextricably connected.
iii. Reducing Automotive Usage in Downtown: We will pro-actively seek to reduce downtown dependence on the automobile whenever possible.
iv. Transition Zones at Downtown's Edges: The heights and densities of downtown should begin to scale down toward the neighborhoods.
v. A Preference for Pedestrians: The community wants a downtown that has a walk-able scale and is considered pedestrian friendly.
vi. Maintaining the Retail Street: We must act to protect, preserve, and enhance the downtown retail core.
vii. The Commons as a Transit Hub: The Commons should be considered a key part of the community's public transit system.
viii. In ‐ Fill Development: In-fill development is an environmentally conscious way to maximize limited downtown real estate.
ix. Clustered Destinations: There is a need for the community to seek to cluster pedestrian foot-traffic generating uses into downtown.
x. Downtown as a Community Center: Downtown should remain the community's focal center for major events, celebrations, and community gatherings.
xi. A Leader in Green Practices and Sustainability: Downtown should serve as a showcase for the community's broader interest in green and sustainable practices.

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Appendix H – Technical Advisory Committee (TAC)

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Technical Advisory Committee

Joe Turcotte	Executive Director, Tompkins Consolidated Area Transit (TCAT)
Ed Marx	Commissioner, Tompkins County Planning Department
Marian Brown	Sustainability Coordinator; Office of the Vice Provost, Ithaca College
Phyllisa DeSarno	Economic Development Director, City of Ithaca
Fernando de Aragon	Executive Director, Ithaca - Tompkins County Transportation Council (ITCTC)
Chris Haine	Public Works & Engineering, City of Ithaca
Mina Amundsen	Director of Planning, Cornell University
Tanya Husick	Department of Planning, Transportation & Mail Services, Cornell University.
Dan Cogan	Alderman, Common Council, City of Ithaca
Tim Logue	Transportation Planner, City of Ithaca
Gary Ferguson	Director, Downtown Ithaca Alliance (DIA)
Carolyn Peterson	Mayor, City of Ithaca
Herb Engman	Supervisor, Town of Ithaca
Bill Wendt	Director, Transportation & Mail Services, Cornell University
JoAnne Cornish	Director, Department of Planning, City of Ithaca
Nancy Oltz	Executive Manager, TCAT
Bill Grey	Director, Department of Public Works & Engineering, City of Ithaca
John Cantor	Director, Department of Planning, Town of Ithaca

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Appendix I – TAC Meeting Minutes

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Feasibility of PRT in Ithaca, NY
Technical Advisory Committee (TAC)

Meeting **1** | Minutes

June 22, 2009 ~ 10am
Tompkins County Public Library
Borg Warner Room

Presenters and Facilitators

C&S Companies –

Paul Wilke (Presenter)

Connect Ithaca, LLC –

Jacob Roberts (Presenter & Facilitator)
Robert Morache (Presenter)
Jason Demarest (Presenter)
Frost Travis (Panelist)

Scott Hamilton (Note Taker)

Stakeholders Present

Joe Turcotte	Executive Director, Tompkins Consolidated Area Transit (TCAT)
Ed Marx	Commissioner, Tompkins County Planning Department
Marian Brown	Sustainability Coordinator; Office of the Vice Provost, Ithaca College
Phyllisa DeSarno	Economic Development Director, City of Ithaca
Fernando de Aragon	Executive Director, Ithaca - Tompkins County Transportation Council (ITCTC)
Chris Haine	Public Works & Engineering, City of Ithaca
Mina Amundsen	Director of Planning, Cornell University
Tanya Husick	Department of Planning, Transportation & Mail Services, Cornell University.
Dan Cogan	Alderman, Common Council, City of Ithaca
Tim Logue	Transportation Planner, City of Ithaca
Gary Ferguson	Director, Downtown Ithaca Alliance (DIA)

Stakeholders Absent

Carolyn Peterson	Mayor, City of Ithaca
Herb Engman	Supervisor, Town of Ithaca
Bill Wendt	Director, Transportation & Mail Services, Cornell University
JoAnne Cornish	Director, Department of Planning, City of Ithaca
Nancy Oltz	Executive Manager, TCAT
Bill Grey	Director, Department of Public Works & Engineering, City of Ithaca
John Cantor	Director, Department of Planning, Town of Ithaca

The first Technical Advisory Committee meeting was held for the Feasibility of PRT in Ithaca, NY study on **June 22, 2009**. Following is a summary of items discussed during that meeting as understood by the preparer. These draft minutes are open for comment and revision by attendees until October 16, 2009 after which they will be considered final and will be filed for the record.

Preliminary Feasibility Study for PRT in Ithaca, NY | Summary

The first Technical Advisory Committee (TAC) meeting was prepared to formally introduce the NYSERDA sponsored preliminary feasibility study for Personal Rapid Transit (PRT) in Ithaca, NY, and its team of principal Investigators, to the local stakeholders who are participating on the study's Technical Advisory Committee.

After delivering a brief introduction of the study's participants, purpose, scope and timing, Paul Wilke of C&S Companies shared his firm's interest in exposing the potential benefits PRT poses in the areas of encouraging more Transit Oriented Development (TOD) / Nodal Development; reducing overall Vehicle Miles Traveled (VMT); advancing the use of more sustainable and clean forms of energy while also reducing consumption levels; improving the natural and built environment; and creating the space for a richer, subjective, quality-of-life approach to future investment and development in both urban and rural areas.

To quote from his introduction:

"We (C&S) are researching the feasibility of PRT in Ithaca and other cities. Why? We recognize the heightened attention on PRT and its application…and our study hopes to expose the synergy and benefits PRT poses for Transit Oriented Development (TOD) benefits vis a vis Vehicle Miles Traveled (VMT), energy, environment, and a subjective, quality-of-life approach…"

Paul distributed to all TAC members a list of the most recent and most relevant studies that have been gathered by investigators, and referenced a list of additional data needs, requesting assistance in pulling it all together.

List of Studies

2025 Long Range Plan, ITCTC
Collegetown Vision Statement
ITCTC Park & Ride White Paper
Cornell Master Plan
NESTS Transit Planning Project
NY Route 13/366 Corridor Management Plan
NY Route 96 Corridor Management Study

Tompkins County / Cornell Employees Survey
Tompkins County Comprehensive Plan

Requested Information

Cornell 10-year Transportation Plan
Carbon Footprint Analysis
TCAT Bus Ridership Data (based on proposed PRT routes)
Land Use / Zoning Maps
Tax Parcel Information to Assess RoW Requirements

Some TAC stakeholder members offered immediate assistance in the following ways:

- Tanya Husick agreed to provide a copy of the Cornell 10-Year Transportation Plan

- Joe Turcotte noted that TCAT can provide Bus Ridership Data. He requested that the consultant team define the information it is seeking. They have monthly and annual ridership and volumes by route.

- Tim Logue informed the room that interactive Land Use/Zoning Maps are available on line, and that an on-line Tax Parcel Information database is maintained by the County. Investigators can also contact the assessment office to get the name of property owners, if interested.

- Fernando's office (ITCTC) offered to provide help with this effort, as well.

Paul presented members with **Technical Memorandum 1 (TM1)** ~ *the State of the PRT Industry;* a summary document each stakeholder received prior to the first TAC meeting. He shared that in the initial meeting, a few aims outlined were to answer any questions about TM1, to begin to present the PRT route selection process, to activate healthy debate and discussion, and for investigators to gather advice around the feasibility of establishing, implementing and managing a new and unique transit product, such as PRT, within Ithaca, NY.

Paul revealed that, as the case for PRT interests C&S for its technical possibilities, it simultaneously intrigues Connect Ithaca for its potential to make critical impact in transforming Greater Ithaca into an exemplary sustainable community, i.e. Model Eco-City. In conclusion, Paul acknowledged that by participating in this preliminary feasibility Study for PRT in Ithaca, NY, this study's work team is aligning itself with the priorities being established by NYSERDA and the New York State Department of Transportation (NYSDOT), as evident through their support and advocacy of sustainable for transportation initiatives; such as in this case: *PON 1239.*

Time was given for TAC members to go around the room and introduce themselves.

TM1 | Recap

Jacob Roberts of Connect Ithaca welcomed TAC members and thanked them for their time and willingness to contribute their collective expertise to the process. Utilizing a power-point presentation mixed with a selection of documentary videos and animations, he shared a brief background and history of the innovation itself, the basic premises of how the technology functions, what the new paradigm of super light-weight fixed-route transit suggests for urban planning, what is the status of an emerging PRT industry world-wide, and also presented real examples of PRT products and systems which are in various stages of development around the globe.

The presentation addressed some key lessons investigators have learned about PRT from TM1. Jacob touched on various aspects of the innovation, including a brief of the history and evolution of the existing technology, commercialization, and the recent market-place introductions in Europe and the Middle East. He explained that TM1's research indicates that a safe, certifiable PRT product, meeting the population, geographic and climate needs of Ithaca, NY, is now available "off the shelf", and that all indicators lean toward more styles and variations becoming available for regular civic use relatively soon.

He recommended that members refer back to TM1 for a more elaborate summary of these findings.

To help frame the readiness and authenticity of the technology and overall philosophy of achieving efficient and effective mass transit via Automated People Movers (APMs), and Personal Rapid Transit, in particular, Jacob presented information that referenced versions of PRT that have served their purpose successfully in existing built environments, such as the systems in operation in Morgantown, West Virginia, and at Duke University.

Jacob noted that the Morgantown, WV Group Rapid Transit (GRT) system is a good case study for the licensing, construction and management of PRT in Ithaca, and in the US. Although the Federal Government financed the initial construction of the 8.2 mile network, West Virginia University is the current owner / operator.

Having been built in the mid 1970's, the core technology and design model is over 30 years old and out of date, nevertheless, it has run for millions of miles with virtually uninterrupted service over that same period, making an average of 16,000 trips per day through four unpredictable seasons (including heavy snowfall), up and down similar grade hills as found in Ithaca, and all without one reported death or serious injury.

In addition the operation is made financially solvent through a $65 fee levied by the University per student, per semester, plus by charging $0.50 per trip for non-students. In sum, there is no ongoing government subsidy to operate or maintain the system – it is a private enterprise that is and has been in the black since its inception.

While the WVU-GRT business model could act as a good template for PRT development in newly constructed mixed-use residential-commercial areas that are still in the planning phases, and on private property such as at Airports and Universities, where more autonomy is available in the decision making around its developing its own land–use and transit policies and projects, Jacob reminded the group that is important for Ithaca's TAC members to consider how a municipality, or local government, plays a role in the process of adopting and deploying automated, electric transportation solutions to serve their long range planning goals in today's political / legislative landscape.

To date, other than the Morgantown GRT system, there is no current PRT operating in an urban environment. Jacob shared that there are, however, numerous driverless APMs in service in many major cities (Las Vegas, Detroit, Miami), and a few modern PRT applications being built around the world, such as at Heathrow Airport in the UK; and at MASDAR, a new city in the Unite Arab Emirates being built from the ground up as a carbon-neutral, car free metropolitan center for 50,000 residents, a business park, commercial district, and a new MIT campus, all powered by the wind and sun. Additionally, over twenty international cities, including a handful in the US, have been identified to have expressed a recent interest in learning more about PRT; some going as so far as to release Requests for Information and Requests for Qualification (ie. San Jose & Santa Cruz, CA).

At this early stage of the feasibility research, major consideration for the participating TAC stakeholders should be aligned with discovering an appropriate fit for Ithaca; an honest assessment of when, where, and how a PRT implementation could occur, and why. To address the oft asked question of whether or not Ithaca / Tompkins County qualifies as "big enough" to warrant such a transit circulator, Jacob shared that the next phase of the feasibility study will provide investigators with the appropriate density metrics to not only demonstrate the population criteria required for system viability, but also the effect PRT could have on facilitating urban densification; in other words, increasing the amount of convenient, attractive, efficient, and affordable housing in the Ithaca core.

It was proposed by one TAC member that altering the DPW's formula for determining zoning density could help increase the proportion of homes developed to meet growing demand, which is projected to be an additional 4000 homes over the next decade. Furthermore, density research in the Booz Allen Hamilton New Jersey PRT study indicates Ithaca already exceeds the threshold population necessary for PRT viability.

While there are many examples of PRT having been rejected for proposed use throughout a variety of different scenarios in the past, whether it for technical, financial or political reasons (or a combination of all three), there is enough contemporary evidence to suggest that the continued evolution, investment, and commercialization of modern PRT mobility system infrastructure is no longer a question of "if?", but "when?" and "where?".

Jacob reminded the group that in deciding on purchasing ULTra PRT for Heathrow Airports' Terminal 5 (the world's 10th largest Airport all by itself), the British Airport Authority (BAA) conducted a rigorous three year, multi-million dollar study on the impacts, effects and efficiencies of a myriad of products to serve the bustling airport; and after scrutinizing the performance of bus, mono-rail, subway, taxi, and other forms of transit, PRT came out on top. Suggesting that if a mega-corporation, like BAA, or the US Government in the 1970's, or the developers of an entirely new eco-City, like MASDAR, confirm the readiness of PRT with such massive investments in PRT infrastructure, then the indicators confirm the product is ready for implementation in other, similar, environments.

Beyond some general inquisitiveness expressed by TAC stakeholders in the areas of operating agreements, establishing a dedicated right of way, and estimating maintenance costs and scheduling, members expressed an overall understanding for how a PRT system works and why a light weight, electric, and driverless central mobility system is worth considering as a long range planning tool for the region, county and city. Jacob told the group that more precise details about an Ithaca-specific system will be addressed in detail in upcoming Technical Memos and in subsequent presentations to the TAC.

As a way to further learn about best practices, TAC members requested more information from investigators about possible public/private financing models, identifying possible revenue streams and other government support resources, and to provide examples of transit agencies aiming to use new technologies, such as PRT, in the US who may have struggled in the process of moving a similar endeavor forward as planned; what were the barriers to implementation. It was also added that focusing on partnering with only one PRT manufacturer may be a risk to flexibility at an early stage of project development.

Jacob noted to the group that with PRT being such a new transit product, having to be built from scratch, there are many potential economic inputs and drivers not only on the commercial side of operations, but also with conducting advanced academic research and development, in partnership with area colleges, universities and research firms; the opportunity to enroll local businesses into the supply chain of PRT manufacturing and assembly; the possibility of partnering an emerging industry leader, complete with private resources and assets, into a joint-venture with the regional transit agency as an early seed project and case study for establishing the first significant Pilot PRT Project in the US; and additionally, the boom of new dedicated real estate development in and around newly constructed PRT stations, thus growing the local tax-base, bringing more citizens closer to downtown jobs, school, goods and services, while simultaneously meeting the growing housing demands.

Investigators, therefore, stressed to TAC members that conducting an honest analysis of what would be the potential positive and negative impacts of introducing PRT into an existing, urban, mixed-use environment as critical to determining the project's feasibility in the US, as most of its urban form has already been established.

Key items that need to be addressed by the group next include: minimizing visual impacts; identifying other state and federal support; acknowledging the 50+ year history of PRT engineering testing and research; considering modern finance and development models; and understanding the unique nature of routing PRT systems.

Technical Memorandum 1 (TM1) | Q&A

Fernando - What was learned from TM1? Who is building PRT now?

Jake - ULTra and Vectus are building PRT now. Lessons of TM1 - From an industry perspective the market entrance is already happening, but its growth is yet to be seen. Financing and Technology is robust and ready, what is left is the political will – the leadership. Does Ithaca fit to be the first Podcar City in North America?

Frost - There are other cities with mild climates and environments who are interested in PRT; however, Ithaca's weather and varying terrain is unique and a challenge. So, if PRT proves to be feasible here, it can be done anywhere. We can set an example and LEAD growth, which is being determined by this objective research study.

Jake – Vectus, a POCO subsidiary, has already tested its product for all conditions in Sweden and is ready to develop their first passenger network.

Ed Marx - is there a threshold population density for fit? Please note the Ithaca area has only seen 1000 new homes in past 10yrs, even though the demand for housing may be 4-5 times as much. Do we need to know population density needs before selecting the route?

Paul - This feasibility study will provide density metrics to understand population criteria for PRT.

Rob - A long-term study in NJ shows PRT needs a minimum of about 20k jobs and 30k residents within proximity of the route footprint. Ithaca meets or exceeds this minimum. Furthermore, TOD and PRT is a tool to improve density - it will attract a bigger portion of housing demand for development. And, PRT as a feeder to other mobility modes allows for up-scale in demand - expands market limits. Also consider the possibilities for light freight and mail services to diversify and expand the market.

Frost - PRT can help provide for more densification by taking the car and garage out of the equation and there are studies that show clear demand for housing, which is increasing in Ithaca.

Ed Marx - city said they can do a MAX of 1/4 of that housing demand in the time needed. Can we do better than what was shown in this study? (see comment above, re 1000 units in 10yrs)

Fernando - think about the paradigm we are working with in terms of zoning. If you adjust the zoning paradigm you can make a way to meet a much bigger portion of housing demand. Not sure if DPW is accounting for the changing of the FORMULA when they are projecting housing development limits.
Tim Logue - who owns and operates PRT? How has it already been done?

Jake - Morgantown is a good example to consider for our case. The Federal Government built the system as a Pilot Test in the '70's, now West Virginia University runs it.

Tim - Morgantown, who did what when system development was being implemented (establishing legislation and rights of way, etc.)?

Jake - Good question, we will find out. We know Morgantown is considering expansion. In Ithaca's case, we see PRT maybe becoming another transit tool for TCAT.

Minna - Has this been tested in urban - mixed use environments? Building where infrastructure already exists is a big need for analysis?

Jake - There is not yet a new system being tested in an existing urban area. Morgantown is only existing system in an urban area, but its technology is not current and not very indicative of modern design applications. Turkey has initiated a pilot test system but it is not yet ready for analysis. Masdar City is being built as we speak; and in addition, the goal for ULTra at Heathrow is to eventually begin to grow to serve metro London.

Minna - A goal is to see HOW this works in a mixed-use environment, and how it works in multiple ways.

Jake - Rob and Jason will address. But, the idea is to create simplification. Let's find a section that serves critical areas in the community to be the DEMONSTRATOR and prove the point of fit for urban and mixed use. We want to identify the most logical route to demonstrate what this can do. Then, we can work into the WHOLE SYSTEMS approach. Also, to address the "enough" population issue – Upstate, NY has an abundance of quality, affordable communities, and has the potential to become a destination for people looking to re-locate and many will be attracted by the arable land, fresh water and quality living conditions offered over the next 20-50 years.

Tim - It will be interesting to look at cities that researched PRT and decided NOT to implement. It will be valuable to see WHY they made their decision.

Jake - When other cities were investigating PRT the infrastructure, scale, and tech was big, highly impactful, and not as efficient as the current industry options. Now, it has been reduced, refined, and streamlined. Yes, we wish to know any other reason why others said no. It must be looked into with those who WANT it as well. e.g. Swedish cities, Santa Cruz, San Jose, CA.

Joe Turcotte - Money question - costs and long-term: is this grant all there is??

Jake - There are a lot of different economic inputs and drivers. Real estate developers and utility providers have an opportunity to benefit through integration with physical transit network. Morgantown numbers are very strong in this regard. Franchising an aggregate right of way for utility infrastructure should be looked into as well.

Scott - This is an attractive venture because of the cost benefit possibilities with the system in place. With federal support (or possibly without), private capital and other investment strategies will follow suit. Disruptive and transformative innovation is popular in the private sector these days.

Joe - There's an important new technology - electric bus – for example, in Savannah GA - vendor didn't support tech operation and maintenance as much as they should have and they are facing significant challenges. TCAT is using the #1 bus Co. for their hybrids and are still having issues. With this in mind, there seems to be a risk with only having one manufacturer. Will one vendor be around to support long-term?

Jake - As an example in PRT industry, Vectus is a heavy investor in developing their own product and wants a heavily active role when they enter market with their first system. They eventually want to license rights to the technology, but in the mean-time they have been pretty forthcoming that they wish to work in partnership with O&M stakeholders throughout the life of their first project.
Joe – We (TCAT) heard same pitch with electric buses. This is just a warning.

Paul Wilke - Joe Turcotte voiced a concern (in side conversation) about the # of TCAT employees that would be lost or gained as a result of PRT.

Route Design and Planning | Brainstorm

Rob Morache and Jason Demarest, of Connect Ithaca, presented the proposed **Phase 1 Pilot PRT Network** layout and configuration. Together, they described the route prioritization scheme, presented various options and initiated the discussion to help examine and scrutinize the various alternatives on the table. By referencing maps, drawings, and renderings of the Ithaca urban area, the group identified key destination areas first. Rob and Jason suggested that the strategy for route placement be that the fixed PRT structure should serve current population nodes and major points of interest, to define districts and corridors appropriate for new mixed-use development, and to connect riders to complimentary modes of mobility; such as bus, bike, and high-speed rail.

A presentation was made that detailed some of the key factors which affect route selection, including working with at grade, or elevated tracks; single vs. double tracks; side vs. center loading on streets; interaction of PRT track with tree canopies; the massing effects of intersections and stations; and the integration and consolidation of overhead utilities. Stakeholder input was requested after Rob and Jason made recommendations based on layout goals to reduce impacts while maximizing connectivity and development potential.

Some of the TAC member comments were as follows:

● At Cornell University, it was preferred that the main terminus be located in Collegetown and not on campus.

● At Ithaca College, an alternate access via the service road was preferred instead of an entry at the main gate.

● At the West End of the track, extending the Phase 1 an extra quarter mile to Wegmans was considered of critical importance to ensure student ridership and maximize the number amenities available to residents who frequent the “Big Box” shopping area, and to new residents of potential new housing developed along State Street and Route 13.

The discussion period revealed several visual impact related concerns within the TAC group:

● It was debated as to whether to concentrate or distribute the overall impact of overhead tracks, i.e. to place double track with high visual impact on fewer streets or single tracks with lower visual impact distributed over more streets.

● The impact of stand-alone stations was a concern and it was suggested to minimize their number, if possible.

Also discussed were thoughts about the location of maintenance and storage facilities; the number of pods needed to meet demand; the true percentage of community trips captured by route; how to establish rights of way on State, County, and City roads; and the safety hazards of placing an electrified track at grade.

Other questions addressed the subjective areas of PRT use:

● The benefit of the speed inherent of PRT transit was contrasted with the possibility of having pods purposely slow through shopping areas to induce riders to browse and shop as an added benefit to commercial districts.

● The idea that the PRT system should allow for “demand stops” was supported (allowing for a change of mind about the intended destination).

● TAC members suggested we expand the range of destinations, improving access to more commercial and/or higher traffic zones, like the High School for example. (It became important, however, to note that the route and area being examined was limited by the parameters of the feasibility study, and that investigators will inevitably capture a portion of the community's potential trip count, when focused only on the defined study area)

It was agreed, none the less, that the Pilot Phase 1 route does indeed identify the major destinations the PRT network should serve in order to establish a viable city “circulator”, and to also help activate future transit oriented housing development, which is one of the core objectives to achieve in the pursuit of reducing VMTs.

Route Design and Planning | Q & A

Fernando - The important attraction of PRT is a small footprint. Minimizing impact might not work at all with double track. Staying with single track lines may need to be a priority.

Rob - This would remove the State Street option from consideration (i.e. single tracks would go on Seneca and Green streets).

Fernando - Yes, and that is what Ithaca needs.

Jake - With this scenario, should we consider extending the commons – the pedestrian footprint, as well?

Rob - Stations on Green ST and Seneca ST would provide easy access to State ST And, there are certain sections in which a double track would still appear minimal.

Jason - It's possible that you won't see double tracks unless you are at intersections (what do you think?). The single track renderings seem minimal when walking on the sidewalk.

Ed Marx - What is the impact of a station? If you bring stations and track to too many places it exponentially increases the potential for major community conflicts. i.e. double tracks will reduce opportunity horizon for conflicts; being in fewer locations.

Rob - Are you proposing a transformation by way of strategically fewer stations and double tracks?

Ed Marx - Developers on State have the most to benefit. [State St. would be option for double track scenario]

Minna - What about tracks at ground grade level?

Jason - That is an option.

Rob - The issue at ground level is the electrified rail at ground level and changing the Right of Way significantly on the street level.

Minna - Speed may be an issue because you don't have the opportunity to SEE commercial options. You don't want to bring a commuting mindset to the downtown where the marketplace is important.

Rob - This is an interesting point for design parameters. We can input a slow down for commercial needs in target areas, but is that the convenience priority when in transit or just a human impulse when in a commercial environment?

Minna - if you want a revitalized downtown you must consider speed and infrastructure for access.

Jake - You could have optional per block advertising notifying people of what "retail zones" they are going to. If you have this built into the transit you can separate people who are trying to get somewhere to those who are looking for something.
Rob & Marian - Yes, you can demand stops at will.

Ed Marx - How many trips of this community are we really capturing? A lot of Ithaca's trips occur outside of this study area.

Jason - It is a limitation of the study, but we do plan to include the areas beyond this very project's scope at some point in the future.

Rob - PRT is not a point A to point B technology. It's a tool to catalyze long-term (i.e. sustainable) development. We need a way to create more attractive options for people to move into town by making it an advantage compared to living outside, and easy to keep their cars on the periphery.

Tanya - Are you eliminating other transit services to assume more ridership? If so, bad idea. How many pods will be used?

Rob - Other services will be integrated, not eliminated, to create an optimal scenario with all mobility modes and other services. Pod numbers are based on ridership. 100% of demand will be met.

Jason - We are making our initial assumptions to activate density development as research criteria in the study. We want to capture more of an opportunity horizon than just the Study parameters to understand the comprehensive impact.

Tanya - Storage and maintenance must be considered even with first phase and included in cost analysis. Consider showing O & M service areas for PRT on the routes and evaluate the impact of their footprint.

Rob - We are researching this as well. And the cost structures of riding pods v. pod maintenance.

Joe T - Disability considerations?

Rob - System producers are taking this into account in product development. It seems that all disability needs will be met.

Frost - Any other key specifics, questions, or comments?

Dan Cogan - This is interesting. I like the densification premise, as expansion then becomes gravy, smart. Because PRT hasn't been in an urban setting, what about vandalism and monitoring risk situations?

Rob - These risks are considered with the Operations and Maintenance research in the study.

Jason - PRT smart system technology allows you to know who is riding by way of ridership card - transacts rides.

Rob - We can expose all possible surveillance levels to determine what community wants.

Tim L. - State owns Seneca and Green. City doesn't own College Avenue? And, the county owns what? What about utility Right of Way?

Jake - Gary Frederick with NYSDOT has stated that ROW won't be too big of an issue; the bigger question is just how it gets paid for...

…keep in mind that the Utility Right of Way could be made accessible, too.

Tim L. - Financial analysis would be really useful to add to the study.

Frost - It is already a part of the study; a later Technical Memorandum.

Jake - Franchise scenario correctly seems optimal for ROW. To be determined in study analysis.

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Appendix J: BeamEd Results

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The conclusion from the simulation results is that the physical configuration of the Study Route has become the limiting factor in terms of feasibility. In the simulation results the critical operational limits of maximum crossing delay and percentage of departure waits represent guidelines recommended by the software. These limits require additional investigation to fully understand the impacts but suggest that at times of peak ridership the system begins to have unnecessary congestion due to the control system having to slow vehicles prior to crossings and merge points. It is logical that a system operating with very low headways of 1-3 seconds cannot handle a crossing delay of much more than 10 seconds without the line behind the crossing backing up. When more than 25% of the vehicles are waiting to depart the system arrivals are prevented, resulting in congestion at the stations. This percentage is understood to be system wide and not at one station. A greater percentage of departure waits would cause patrons to have to wait at the stations and starts to erode the convenience factor cited by PRT advocates. However, it should be noted that the main variable in each of the BeamEd simulation scenarios is the number of vehicles in the system which were increased to obtain simulation results within the operational limits of the software. As an example, in Scenario 1, the system did not perform within operational limits with 425 vehicles and required 450 to satisfy the limits. This suggests that a high percentage of departure waits can also be a result of too few vehicles in the system. Therefore the system design needs to be adjusted to provide the most efficient operation.

For clarification the line speed for most of the scenarios was set slightly higher then the average 25-30 mph (12.5 meters per second) speed referenced earlier in this report since the Study Route has few crossings or merging intersections that would reduce average speeds. Likewise the route is more of a line haul layout that would allow higher speeds in the long sections of uninterrupted travel and subsequently increase the average system speed. Regardless, significant benefits in the simulation results are not produced by setting the average speed higher than that suggested by the industry. In fact if you compare Scenario 6 with Scenario 10 where the only difference is average speed the maximum crossing delays are only 5.6 and 8.5 seconds respectively, and the percentage of departure waits are only 12.6% and 13.7% respectively.

In order to understand the magnitude of these operational limits some comparative simulations were run. The results shown in Scenario 4 are based on 1 second headways, which is a deviation from the 2 second headway used in Scenarios 1 and 2. This is important to consider especially since current safety approvals are for a minimum headway of 3 seconds. Simply changing the headway to 2 seconds resulted in excessive crossing delays and a higher percentage of departure waits at 271 seconds and 91.8% respectively. It should be noted that all of the results are based on the system operating in a peak demand scenario of 5,500 riders per hour in the year 2030 and a significant portion of this ridership, ~2,500, is a result of transit oriented development (TOD). Analyzing the Study Route, which has a very limited system size and configuration for the purposes of the study, with the projected ridership demand for the year 2030 is somewhat inconsistent. While it is possible that the PRT system may not expand over the next twenty years, it is unlikely. Likewise the Study Route represents an initial pilot system configuration, which is expected to be smaller than a complete initial system. However, this analysis is simultaneously looking at present day feasibility as well as in the future.

In terms of present day feasibility a peak ridership figure of ~3,000 riders per hour may be more realistic since the ridership from TOD would take time to develop. Looking at a comparative simulation in Scenario 2 with a 33.5 mph average speed, 2 second headways, and a ridership demand figure of 3,000 the crossing delay and percentage of departure waits are 6.8 seconds and 12.1% respectively. Therefore it is feasible for the Study Route to operate effectively if constructed in the near future and assuming a PRT system achieves safety approval for 2 second headways, which is a small decrease over the 3 second approval that Vectus has currently obtained. Another interesting conclusion is that while it might seem intuitive to reduce the average system speed to slow the rate of congestion the opposite tends to occur. Running this same simulation with a demand figure of 3,000 and a 12 mph average speed (The average speed for intra-city bus travel) actually causes the system to operate outside of operational limits. In the future, however, the system would either need to expand into a network to handle any additional capacity or utilize more dual direction guideway. The Study Route modeled in the simulation is essentially a line haul configuration with a one-way loop around The Commons to create an exchange at the core to feed the three end-of-line destination points. There are also one-way loops near Wegmans and in the South Hill/ Emerson area. Surprisingly making a simple change to all dual-direction guide-ways along the Study Route has a significant impact. Inherently this begins to emulate a networked system since it provides for alternate routing through the system core. In Scenario 8 this simulation results in 4.2 second crossing delay and 20.15% departure waits with a 33.5 mph average speed, 1.5 second headways, and a ridership demand figure of 5,000. Even at 28 mph (approximation of the 25-30 mph industry average) the results in Scenario 12 are 3 second crossing delay and 17.7% departure waits. Finally, adjusting the software inputs to 33.5 mph average speed, 3 second headways, and a ridership demand figure of 3,000 in Scenario 6 the crossing delay and percentage of departure waits are 5.6 seconds and 12.6% respectively. This is within the Beamways' software operational limits as well as consistent with current safety approvals for the Vectus system.

Scenario 1-		**Study Route configuration**	
Assumptions:			---------------------------
			Simulation results
	Demand:	3,000 pph	---------------------------
	Velocity:	33.5 mph	Total length of single direction lines: 6.9 km
	Headway:	2 seconds	Total length of dual direction lines: 3.2 km
	Vehicles:	425	Total length of station and xing ramps and switches: 7.5 km
			Total (single) track length: 20.8 km
Simulation Results:			Weighted total track length: 19.2 km
			Added track for ramps and switches: 63.8%
	Vehicles Required:		
	Insufficient		**Number of vehicles: 425**
	Track Crossing Delay:		Number of stations: 23
	Exceeds limits		Number of berths: 108
	Departure Waits:		Number of 3 way crossings: 10
	Exceeds limits		Number of 4 way crossings: 0
			Total number of crossings: 10
			Mean trip distance: 2.2 km
			Mean trip distance along a straight line: 0.9 km
			Unloaded mean speed: 43.8 km/h
			Unloaded mean speed, compared to straight line distance: 22.1 km/h
			Simulation conditions:
			Population: 29992
			Work places: 14989
			Shops: 7491
			Simulation results:
			Max number of vehicles moving: 410
			Mean vehicle use: 47.2%
			Mean simulated speed: 25.8 km/h
			Mean simulated speed, compared to straight line distance: 12.9 km/h
			Network usage max: 59.1%
			Max xing delay: 149.1 s
			Number of full trips made: 3005
			Number of empty trips made: 1231
			Total number of trips made: 4236
			Empty to full trip count ratio: 40%
			Total distance of all full trips: 8046.2 km
			Total distance of all empty trips: 2787.2 km
			Total distance of all vehicles: 10833.4 km
			Empty to full distance ratio: 34.6%
			Average full trip length: 2.7 km
			Average vehicle distance per trip made: 3.6 km
			Mean departure wait of all departures: 23.5 s
			Percentage departure waits: 36.8%
			Mean departure wait for those who have to wait: 63.8 s

Scenario 2-		**Study Route configuration**	
Assumptions:			---------------------------
			Simulation results
	Demand:	3,000 pph	---------------------------
	Velocity:	33.5 mph	Total length of single direction lines: 6.9 km
	Headway:	2 seconds	Total length of dual direction lines: 3.2 km
	Vehicles:	450	Total length of station and xing ramps and switches: 7.5 km
			Total (single) track length: 20.8 km
Simulation Results:			Weighted total track length: 19.2 km
			Added track for ramps and switches: 63.8%
	Vehicles Required:		
		450	**Number of vehicles: 450**
	Track Crossing Delay:		Number of stations: 23
	Within limits		Number of berths: 108
	Departure Waits:		Number of 3 way crossings: 10
	Within limits		Number of 4 way crossings: 0
			Total number of crossings: 10
			Mean trip distance: 2.2 km
			Mean trip distance along a straight line: 0.9 km
			Unloaded mean speed: 43.8 km/h
			Unloaded mean speed, compared to straight line distance: 22.1 km/h
			Simulation conditions:
			Population: 29992
			Work places: 14989
			Shops: 7491
			Simulation results:
			Max number of vehicles moving: 257
			Mean vehicle use: 40.0%
			Mean simulated speed: 31.8 km/h
			Mean simulated speed, compared to straight line distance: 16.1 km/h
			Network usage max: 37.0%
			Max xing delay: 6.8 s
			Number of full trips made: 3008
			Number of empty trips made: 1118
			Total number of trips made: 4126
			Empty to full trip count ratio: 37%
			Total distance of all full trips: 8041.6 km
			Total distance of all empty trips: 1670.9 km
			Total distance of all vehicles: 9712.4 km
			Empty to full distance ratio: 20.8%
			Average full trip length: 2.7 km
			Average vehicle distance per trip made: 3.2 km
			Mean departure wait of all departures: 3.9 s
			Percentage departure waits: 12.1%
			Mean departure wait for those who have to wait: 32.1 s

Scenario 3-		Study Route configuration	
Assumptions:			---------------------------
			Simulation results
	Demand:	5,500 pph	---------------------------
	Velocity:	33.5 mph	Total length of single direction lines: 6.9 km
	Headway:	1 second	Total length of dual direction lines: 3.2 km
	Vehicles:	475	Total length of station and xing ramps and switches: 7.5 km
			Total (single) track length: 20.8 km
Simulation Results:			Weighted total track length: 19.2 km
			Added track for ramps and switches: 63.8%
	Vehicles Required:		
	Insufficient		**Number of vehicles: 475**
	Track Crossing Delay:		Number of stations: 23
	Within limits		Number of berths: 108
	Departure Waits:		Number of 3 way crossings: 10
	Exceeds limits		Number of 4 way crossings: 0
			Total number of crossings: 10
			Mean trip distance: 2.2 km
			Mean trip distance along a straight line: 0.9 km
			Unloaded mean speed: 43.8 km/h
			Unloaded mean speed, compared to straight line distance: 22.1 km/h
			Simulation conditions:
			Population: 54988
			Work places: 27487
			Shops: 13732
			Simulation results:
			Max number of vehicles moving: 461
			Mean vehicle use: 77.6%
			Mean simulated speed: 33.2 km/h
			Mean simulated speed, compared to straight line distance: 16.0 km/h
			Network usage max: 33.2%
			Max xing delay: 7.9 s
			Number of full trips made: 5515
			Number of empty trips made: 2395
			Total number of trips made: 7910
			Empty to full trip count ratio: 43%
			Total distance of all full trips: 14672.4 km
			Total distance of all empty trips: 5240.7 km
			Total distance of all vehicles: 19913.1 km
			Empty to full distance ratio: 35.7%
			Average full trip length: 2.7 km
			Average vehicle distance per trip made: 3.6 km
			Mean departure wait of all departures: 13.2 s
			Percentage departure waits: 36.0%
			Mean departure wait for those who have to wait: 36.6 s

Scenario 4A-		Study Route configuration
Assumptions:		---------------------------
		Simulation results
	Demand:	5,500 pph	---------------------------
	Velocity:	33.5 mph	Total length of single direction lines: 6.9 km
	Headway:	1 second	Total length of dual direction lines: 3.2 km
	Vehicles:	500	Total length of station and xing ramps and switches: 7.5 km
		Total (single) track length: 20.8 km
Simulation Results:		Weighted total track length: 19.2 km
		Added track for ramps and switches: 63.8%
Vehicles Required:		
	500	**Number of vehicles: 500**
Track Crossing Delay:		Number of stations: 23
	Within limits	Number of berths: 108
Departure Waits:		Number of 3 way crossings: 10
	Within limits	Number of 4 way crossings: 0
		Total number of crossings: 10
Note:		
System exceeds operational limits with 2 second headways under all conditions- see Scenario 4B below		Mean trip distance: 2.2 km
		Mean trip distance along a straight line: 0.9 km
		Unloaded mean speed: 43.8 km/h
		Unloaded mean speed, compared to straight line distance: 22.1 km/h
		Simulation conditions:
		Population: 54988
		Work places: 27487
		Shops: 13732
		Simulation results:
		Max number of vehicles moving: 476
		Mean vehicle use: 68.3%
		Mean simulated speed: 33.9 km/h
		Mean simulated speed, compared to straight line distance: 16.7 km/h
		Network usage max: 34.3%
		Max xing delay: 5.5 s
		Number of full trips made: 5518
		Number of empty trips made: 2409
		Total number of trips made: 7927
		Empty to full trip count ratio: 43%
		Total distance of all full trips: 14687.1 km
		Total distance of all empty trips: 3762.7 km
		Total distance of all vehicles: 18449.9 km
		Empty to full distance ratio: 25.6%
		Average full trip length: 2.7 km
		Average vehicle distance per trip made: 3.3 km
		Mean departure wait of all departures: 4.6 s
		Percentage departure waits: 18.1%
		Mean departure wait for those who have to wait: 25.6 s

Scenario 4B-		Study Route configuration	
Assumptions:			---------------------------
			Simulation results
	Demand:	5,500 pph	---------------------------
	Velocity:	33.5 mph	Total length of single direction lines: 6.9 km
	Headway:	**2 seconds**	Total length of dual direction lines: 3.2 km
	Vehicles:	500	Total length of station and xing ramps and switches: 7.5 km
			Total (single) track length: 20.8 km
Simulation Results:			Weighted total track length: 19.2 km
			Added track for ramps and switches: 63.8%
	Vehicles Required:		
	Insufficient/ NA		**Number of vehicles: 500**
	Track Crossing Delay:		Number of stations: 23
	Exceeds Limits		Number of berths: 108
	Departure Waits:		Number of 3 way crossings: 10
	Exceeds Limits		Number of 4 way crossings: 0
			Total number of crossings: 10
			Mean trip distance: 2.2 km
			Mean trip distance along a straight line: 0.9 km
			Unloaded mean speed: 43.8 km/h
			Unloaded mean speed, compared to straight line distance: 22.1 km/h
			Simulation conditions:
			Population: 54988
			Work places: 27487
			Shops: 13732
			Simulation results:
			Max number of vehicles moving: 500
			Mean vehicle use: 41.9%
			Mean simulated speed: 7.5 km/h
			Mean simulated speed, compared to straight line distance: 3.5 km/h
			Network usage max: 72.1%
			Max xing delay: 272.0 s
			Number of full trips made: 3948
			Number of empty trips made: 117
			Total number of trips made: 4065
			Empty to full trip count ratio: 2%
			Total distance of all full trips: 10981.4 km
			Total distance of all empty trips: 345.2 km
			Total distance of all vehicles: 11326.6 km
			Empty to full distance ratio: 3.1%
			Average full trip length: 2.8 km
			Average vehicle distance per trip made: 2.9 km
			Mean departure wait of all departures: 1372.7 s
			Percentage departure waits: 91.8%
			Mean departure wait for those who have to wait: 1495.8 s

Scenario 5-		All dual-direction guideway configuration
Assumptions:		---------------------------
		Simulation results
Demand:	3,000 pph	---------------------------
Velocity:	33.5 mph	Total length of single direction lines: 1.5 km
Headway:	3 seconds	Total length of dual direction lines: 8.6 km
Vehicles:	225	Total length of station and xing ramps and switches: 8.6 km
		Total (single) track length: 27.3 km
Simulation Results:		Weighted total track length: 23.0 km
		Added track for ramps and switches: 59.6%
Vehicles Required:		
Insufficient		**Number of vehicles: 225**
Track Crossing Delay:		Number of stations: 21
Exceeds limits		Number of berths: 124
Departure Waits:		Number of 3 way crossings: 10
Exceeds limits		Number of 4 way crossings: 0
		Total number of crossings: 10
		Mean trip distance: 1.7 km
		Mean trip distance along a straight line: 1.0 km
		Unloaded mean speed: 43.3 km/h
		Unloaded mean speed, compared to straight line distance: 27.2 km/h
		Simulation conditions:
		Population: 29987
		Work places: 14983
		Shops: 7488
		Simulation results:
		Max number of vehicles moving: 211
		Mean vehicle use: 70.2%
		Mean simulated speed: 33.6 km/h
		Mean simulated speed, compared to straight line distance: 20.6 km/h
		Network usage max: 34.8%
		Max xing delay: 8.1 s
		Number of full trips made: 3011
		Number of empty trips made: 1307
		Total number of trips made: 4318
		Empty to full trip count ratio: 43%
		Total distance of all full trips: 6206.4 km
		Total distance of all empty trips: 2325.7 km
		Total distance of all vehicles: 8532.1 km
		Empty to full distance ratio: 37.5%
		Average full trip length: 2.1 km
		Average vehicle distance per trip made: 2.8 km
		Mean departure wait of all departures: 11.6 s
		Percentage departure waits: 32.3%
		Mean departure wait for those who have to wait: 35.8 s

Scenario 6-		**All dual-direction guideway configuration**	
Assumptions:			---------------------------
			Simulation results
	Demand:	3,000 pph	---------------------------
	Velocity:	33.5 mph	Total length of single direction lines: 1.5 km
	Headway:	3 seconds	Total length of dual direction lines: 8.6 km
	Vehicles:	260	Total length of station and xing ramps and switches: 8.6 km
			Total (single) track length: 27.3 km
Simulation Results:			Weighted total track length: 23.0 km
			Added track for ramps and switches: 59.6%
	Vehicles Required:		
		260	**Number of vehicles: 260**
	Track Crossing Delay:		Number of stations: 21
	Within limits		Number of berths: 124
	Departure Waits:		Number of 3 way crossings: 10
	Within limits		Number of 4 way crossings: 0
			Total number of crossings: 10
			Mean trip distance: 1.7 km
			Mean trip distance along a straight line: 1.0 km
			Unloaded mean speed: 43.3 km/h
			Unloaded mean speed, compared to straight line distance: 27.2 km/h
			Simulation conditions:
			Population: 29987
			Work places: 14983
			Shops: 7488
			Simulation results:
			Max number of vehicles moving: 216
			Mean vehicle use: 55.0%
			Mean simulated speed: 34.5 km/h
			Mean simulated speed, compared to straight line distance: 21.3 km/h
			Network usage max: 35.6%
			Max xing delay: 5.6 s
			Number of full trips made: 3015
			Number of empty trips made: 1087
			Total number of trips made: 4102
			Empty to full trip count ratio: 36%
			Total distance of all full trips: 6218.2 km
			Total distance of all empty trips: 1510.7 km
			Total distance of all vehicles: 7728.8 km
			Empty to full distance ratio: 24.3%
			Average full trip length: 2.1 km
			Average vehicle distance per trip made: 2.6 km
			Mean departure wait of all departures: 3.1 s
			Percentage departure waits: 12.6%
			Mean departure wait for those who have to wait: 24.3 s

Scenario 7-	**All dual-direction guideway configuration**	
Assumptions:		---------------------------
		Simulation results
Demand:	5,500 pph	---------------------------
Velocity:	33.5 mph	Total length of single direction lines: 1.5 km
Headway:	1.5 seconds	Total length of dual direction lines: 8.6 km
Vehicles:	375	Total length of station and xing ramps and switches: 8.6 km
		Total (single) track length: 27.3 km
Simulation Results:		Weighted total track length: 23.0 km
		Added track for ramps and switches: 59.6%
Vehicles Required:		
Insufficient		**Number of vehicles: 375**
Track Crossing Delay:		Number of stations: 21
Within limits		Number of berths: 124
Departure Waits:		Number of 3 way crossings: 10
Exceeds limits		Number of 4 way crossings: 0
		Total number of crossings: 10
		Mean trip distance: 1.7 km
		Mean trip distance along a straight line: 1.0 km
		Unloaded mean speed: 43.3 km/h
		Unloaded mean speed, compared to straight line distance: 27.2 km/h
		Simulation conditions:
		Population: 54987
		Work places: 27487
		Shops: 13743
		Simulation results:
		Max number of vehicles moving: 361
		Mean vehicle use: 77.3%
		Mean simulated speed: 33.1 km/h
		Mean simulated speed, compared to straight line distance: 20.3 km/h
		Network usage max: 29.8%
		Max xing delay: 3.6 s
		Number of full trips made: 5487
		Number of empty trips made: 2303
		Total number of trips made: 7790
		Empty to full trip count ratio: 41%
		Total distance of all full trips: 11641.9 km
		Total distance of all empty trips: 4015.9 km
		Total distance of all vehicles: 15657.9 km
		Empty to full distance ratio: 34.5%
		Average full trip length: 2.1 km
		Average vehicle distance per trip made: 2.9 km
		Mean departure wait of all departures: 13.4 s
		Percentage departure waits: 39.3%
		Mean departure wait for those who have to wait: 34.1 s

Scenario 8-		**All dual-direction guideway configuration**	
Assumptions:			---------------------------
			Simulation results
	Demand:	5,500 pph	---------------------------
	Velocity:	33.5 mph	Total length of single direction lines: 1.5 km
	Headway:	1.5 seconds	Total length of dual direction lines: 8.6 km
	Vehicles:	400	Total length of station and xing ramps and switches: 8.6 km
			Total (single) track length: 27.3 km
Simulation Results:			Weighted total track length: 23.0 km
			Added track for ramps and switches: 59.6%
	Vehicles Required:		
	400		**Number of vehicles: 400**
	Track Crossing Delay:		Number of stations: 21
	Within limits		Number of berths: 124
	Departure Waits:		Number of 3 way crossings: 10
	Within limits		Number of 4 way crossings: 0
			Total number of crossings: 10
			Mean trip distance: 1.7 km
			Mean trip distance along a straight line: 1.0 km
			Unloaded mean speed: 43.3 km/h
			Unloaded mean speed, compared to straight line distance: 27.2 km/h
			Simulation conditions:
			Population: 54987
			Work places: 27487
			Shops: 13743
			Simulation results:
			Max number of vehicles moving: 379
			Mean vehicle use: 68.8%
			Mean simulated speed: 34.1 km/h
			Mean simulated speed, compared to straight line distance: 21.1 km/h
			Network usage max: 31.3%
			Max xing delay: 4.2 s
			Number of full trips made: 5516
			Number of empty trips made: 2336
			Total number of trips made: 7852
			Empty to full trip count ratio: 42%
			Total distance of all full trips: 11694.2 km
			Total distance of all empty trips: 3173.1 km
			Total distance of all vehicles: 14867.3 km
			Empty to full distance ratio: 27.1%
			Average full trip length: 2.1 km
			Average vehicle distance per trip made: 2.7 km
			Mean departure wait of all departures: 4.5 s
			Percentage departure waits: 20.1%
			Mean departure wait for those who have to wait: 22.3 s

Scenario 9-		**All dual-direction guideway configuration**	
Assumptions:			---------------------------
			Simulation results
	Demand:	3,000 pph	---------------------------
	Velocity:	28 mph	Total length of single direction lines: 1.5 km
	Headway:	3 seconds	Total length of dual direction lines: 8.6 km
	Vehicles:	250	Total length of station and xing ramps and switches: 7.3 km
			Total (single) track length: 26.0 km
Simulation Results:			Weighted total track length: 21.7 km
			Added track for ramps and switches: 50.6%
	Vehicles Required:		
	Insufficient		**Number of vehicles: 250**
	Track Crossing Delay:		Number of stations: 21
	Within limits		Number of berths: 124
	Departure Waits:		Number of 3 way crossings: 10
	Exceeds limits		Number of 4 way crossings: 0
			Total number of crossings: 10
			Mean trip distance: 1.7 km
			Mean trip distance along a straight line: 1.0 km
			Unloaded mean speed: 38.8 km/h
			Unloaded mean speed, compared to straight line distance: 24.3 km/h
			Simulation conditions:
			Population: 29987
			Work places: 14983
			Shops: 7488
			Simulation results:
			Max number of vehicles moving: 238
			Mean vehicle use: 76.4%
			Mean simulated speed: 29.4 km/h
			Mean simulated speed, compared to straight line distance: 18.0 km/h
			Network usage max: 34.3%
			Max xing delay: 7.6 s
			Number of full trips made: 3015
			Number of empty trips made: 1336
			Total number of trips made: 4351
			Empty to full trip count ratio: 44%
			Total distance of all full trips: 6202.3 km
			Total distance of all empty trips: 2391.1 km
			Total distance of all vehicles: 8593.5 km
			Empty to full distance ratio: 38.6%
			Average full trip length: 2.1 km
			Average vehicle distance per trip made: 2.9 km
			Mean departure wait of all departures: 12.1 s
			Percentage departure waits: 31.6%
			Mean departure wait for those who have to wait: 38.2 s

Scenario 10-		**All dual-direction guideway configuration**	
Assumptions:			---------------------------
			Simulation results
	Demand:	3,000 pph	---------------------------
	Velocity:	28 mph	Total length of single direction lines: 1.5 km
	Headway:	3 seconds	Total length of dual direction lines: 8.6 km
	Vehicles:	275	Total length of station and xing ramps and switches: 7.3 km
			Total (single) track length: 26.0 km
Simulation Results:			Weighted total track length: 21.7 km
			Added track for ramps and switches: 50.6%
	Vehicles Required:		
		275	**Number of vehicles: 275**
	Track Crossing Delay:		Number of stations: 21
	Within limits		Number of berths: 124
	Departure Waits:		Number of 3 way crossings: 10
	Within limits		Number of 4 way crossings: 0
			Total number of crossings: 10
			Mean trip distance: 1.7 km
			Mean trip distance along a straight line: 1.0 km
			Unloaded mean speed: 38.8 km/h
			Unloaded mean speed, compared to straight line distance: 24.3 km/h
			Simulation conditions:
			Population: 29987
			Work places: 14983
			Shops: 7488
			Simulation results:
			Max number of vehicles moving: 234
			Mean vehicle use: 62.1%
			Mean simulated speed: 30.9 km/h
			Mean simulated speed, compared to straight line distance: 19.0 km/h
			Network usage max: 33.7%
			Max xing delay: 8.5 s
			Number of full trips made: 3015
			Number of empty trips made: 1132
			Total number of trips made: 4147
			Empty to full trip count ratio: 37%
			Total distance of all full trips: 6202.1 km
			Total distance of all empty trips: 1490.6 km
			Total distance of all vehicles: 7692.7 km
			Empty to full distance ratio: 24.0%
			Average full trip length: 2.1 km
			Average vehicle distance per trip made: 2.6 km
			Mean departure wait of all departures: 3.7 s
			Percentage departure waits: 13.7%
			Mean departure wait for those who have to wait: 26.8 s

Scenario 11-	All dual-direction guideway configuration		
Assumptions:			---------------------------
			Simulation results
	Demand:	5,500 pph	---------------------------
	Velocity:	28 mph	Total length of single direction lines: 1.5 km
	Headway:	1.5 seconds	Total length of dual direction lines: 8.6 km
	Vehicles:	425	Total length of station and xing ramps and switches: 7.3 km
			Total (single) track length: 26.0 km
Simulation Results:			Weighted total track length: 21.7 km
			Added track for ramps and switches: 50.6%
	Vehicles Required:		
	Insufficient		**Number of vehicles: 425**
	Track Crossing Delay:		Number of stations: 21
	Within limits		Number of berths: 124
	Departure Waits:		Number of 3 way crossings: 10
	Exceeds limits		Number of 4 way crossings: 0
			Total number of crossings: 10
			Mean trip distance: 1.7 km
			Mean trip distance along a straight line: 1.0 km
			Unloaded mean speed: 38.8 km/h
			Unloaded mean speed, compared to straight line distance: 24.3 km/h
			Simulation conditions:
			Population: 54987
			Work places: 27487
			Shops: 13743
			Simulation results:
			Max number of vehicles moving: 409
			Mean vehicle use: 83.4%
			Mean simulated speed: 28.9 km/h
			Mean simulated speed, compared to straight line distance: 17.7 km/h
			Network usage max: 29.5%
			Max xing delay: 3.3 s
			Number of full trips made: 5500
			Number of empty trips made: 2518
			Total number of trips made: 8018
			Empty to full trip count ratio: 45%
			Total distance of all full trips: 11640.6 km
			Total distance of all empty trips: 4310.2 km
			Total distance of all vehicles: 15950.9 km
			Empty to full distance ratio: 37.0%
			Average full trip length: 2.1 km
			Average vehicle distance per trip made: 2.9 km
			Mean departure wait of all departures: 10.3 s
			Percentage departure waits: 35.5%
			Mean departure wait for those who have to wait: 28.9 s

Scenario 12-		**All dual-direction guideway configuration**	
Assumptions:			---------------------------
			Simulation results
	Demand:	5,500 pph	---------------------------
	Velocity:	28 mph	Total length of single direction lines: 1.5 km
	Headway:	1.5 seconds	Total length of dual direction lines: 8.6 km
	Vehicles:	450	Total length of station and xing ramps and switches: 7.3 km
			Total (single) track length: 26.0 km
Simulation Results:			Weighted total track length: 21.7 km
			Added track for ramps and switches: 50.6%
	Vehicles Required:		
		450	**Number of vehicles: 450**
	Track Crossing Delay:		Number of stations: 21
		Within limits	Number of berths: 124
	Departure Waits:		Number of 3 way crossings: 10
		Within limits	Number of 4 way crossings: 0
			Total number of crossings: 10
			Mean trip distance: 1.7 km
			Mean trip distance along a straight line: 1.0 km
			Unloaded mean speed: 38.8 km/h
			Unloaded mean speed, compared to straight line distance: 24.3 km/h
			Simulation conditions:
			Population: 54987
			Work places: 27487
			Shops: 13743
			Simulation results:
			Max number of vehicles moving: 410
			Mean vehicle use: 70.3%
			Mean simulated speed: 29.6 km/h
			Mean simulated speed, compared to straight line distance: 18.2 km/h
			Network usage max: 29.5%
			Max xing delay: 3.0 s
			Number of full trips made: 5518
			Number of empty trips made: 1999
			Total number of trips made: 7517
			Empty to full trip count ratio: 36%
			Total distance of all full trips: 11667.7 km
			Total distance of all empty trips: 2582.0 km
			Total distance of all vehicles: 14249.7 km
			Empty to full distance ratio: 22.1%
			Average full trip length: 2.1 km
			Average vehicle distance per trip made: 2.6 km
			Mean departure wait of all departures: 4.9 s
			Percentage departure waits: 17.7%
			Mean departure wait for those who have to wait: 27.9 s

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Appendix K: Right-of-Way Sections

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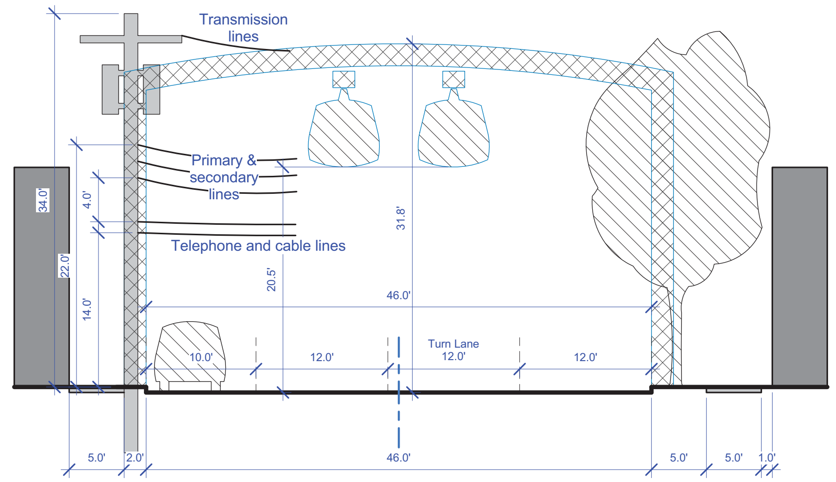
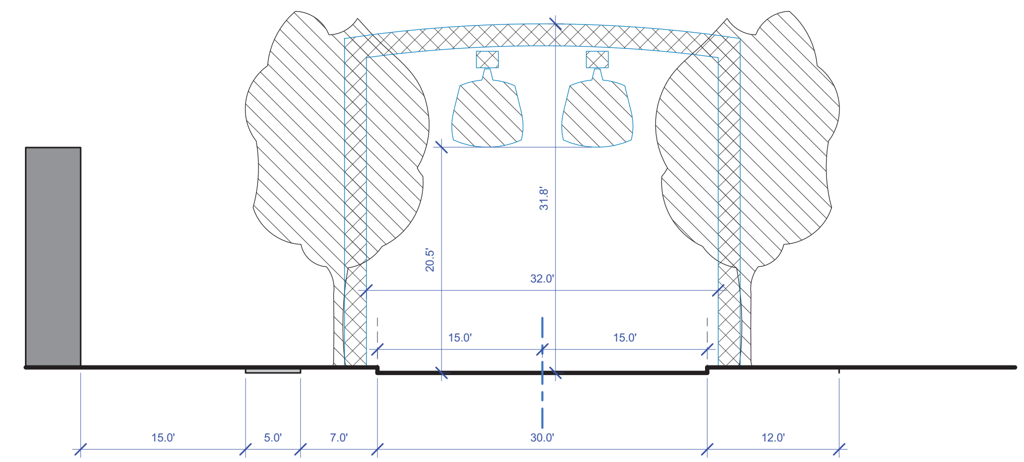
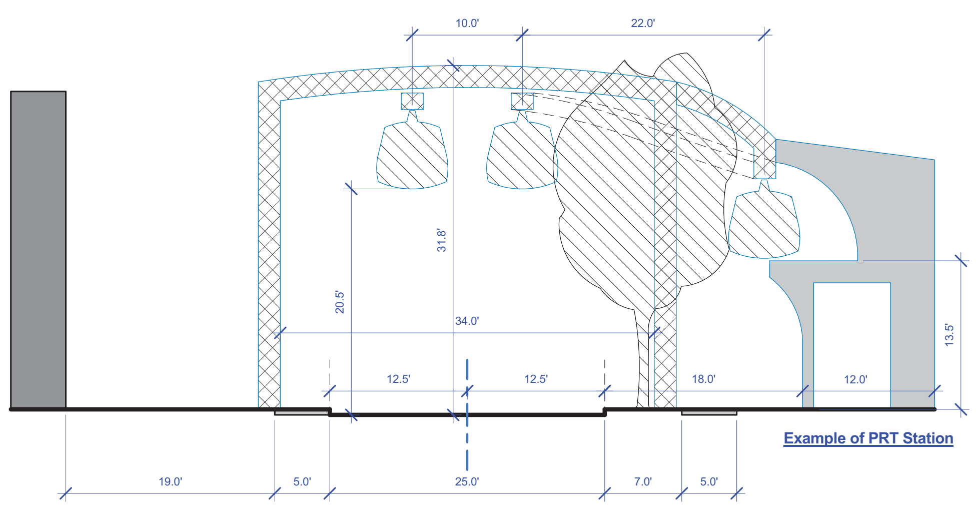


State St (@ Kinkos)

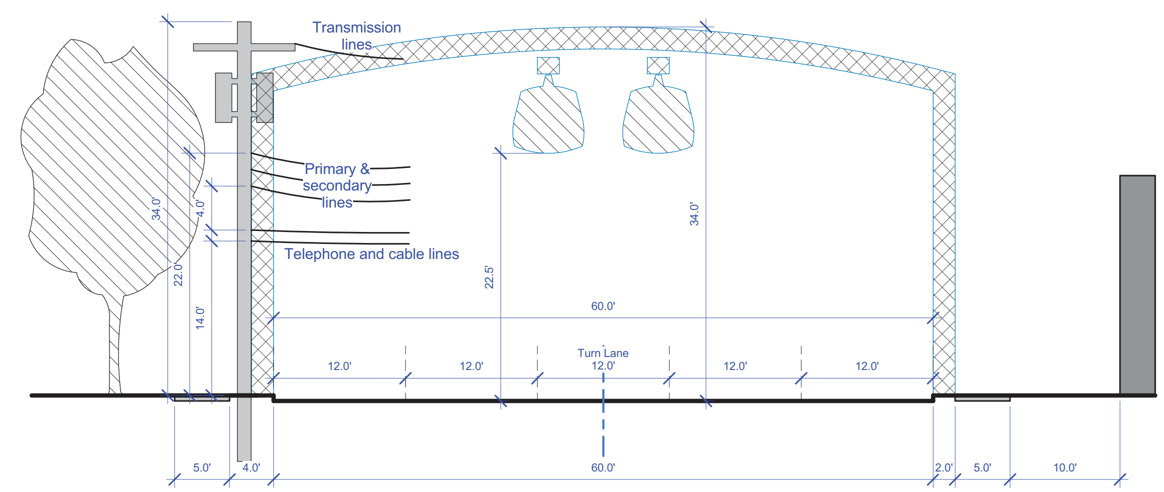


Wegmans Access Road



Fulton St (@ Agway)

Example of PRT Station



Rt 13 South (@ Meadow Court Inn)

8' 4' 0' 8' 16'

SCALE : 1/8" = 1'-0"

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Revisions

Date:

NYSERDA

Personal Rapid Transit in Ithaca, NY

Preliminary

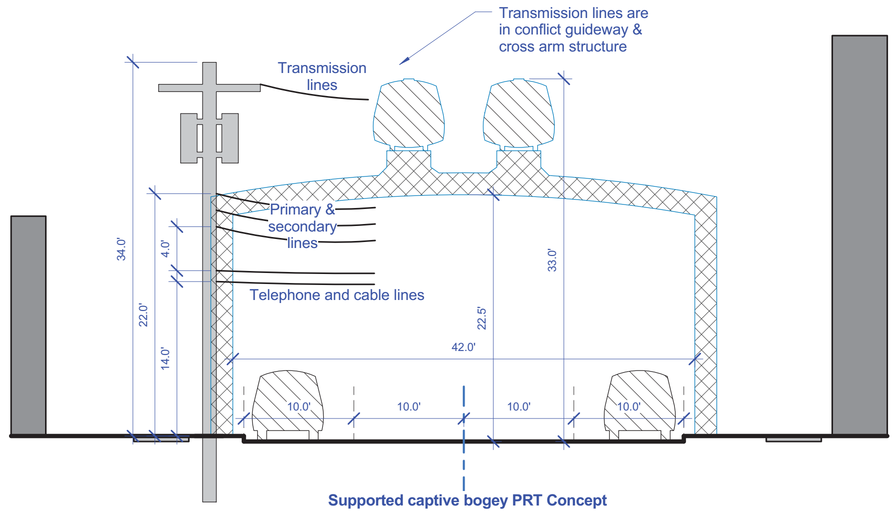
Ithaca, NY

ROW Sections

Project No:	CI-PON1239
Date:	02/09/10
Drawn by:	JKD
Checked by:	JKD

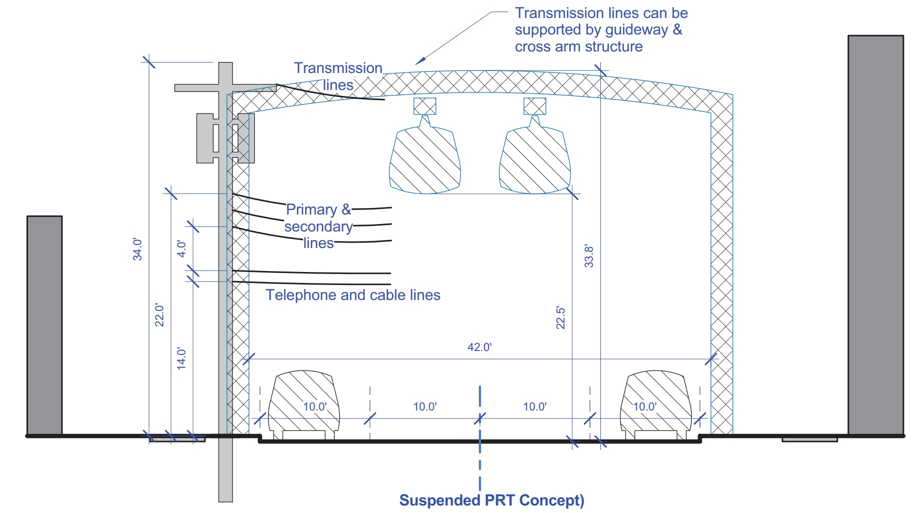
C3.1

Scale: 1/8" = 1'-0"



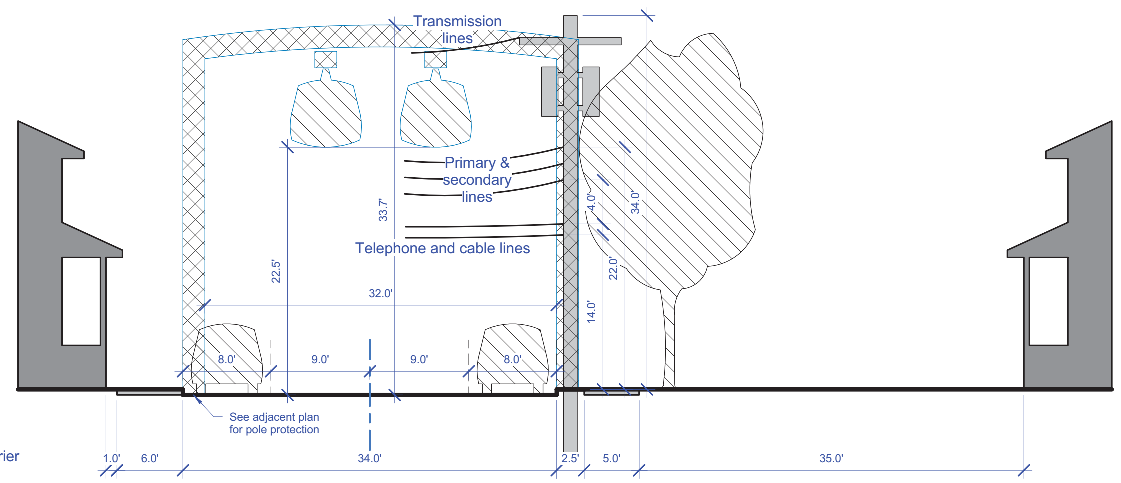
Supported captive bogey PRT Concept

Comparison between a supported and a suspended guideway

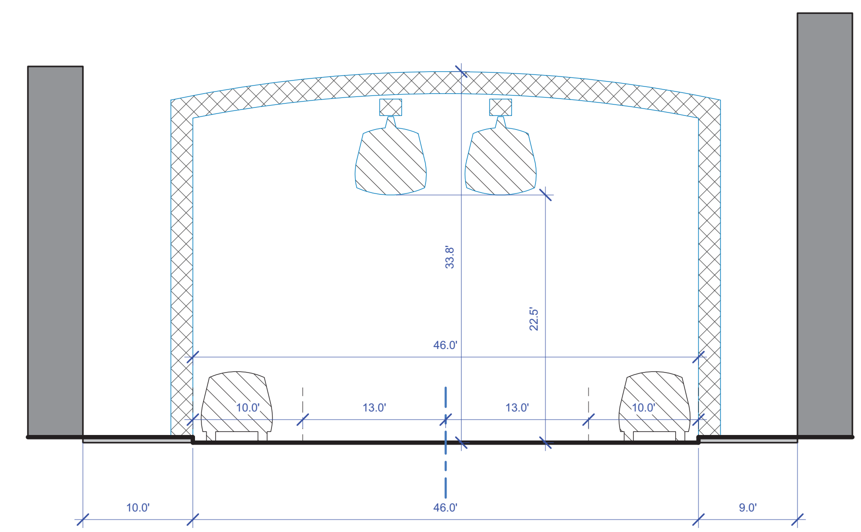


Suspended PRT Concept)

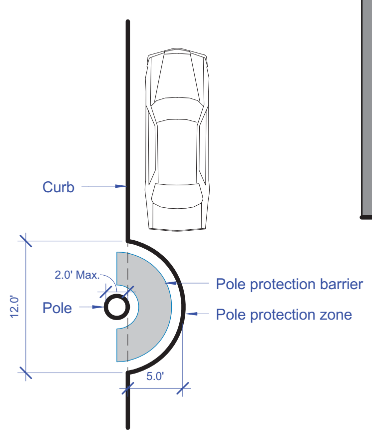
City of Ithaca Street Right-of-Way sections



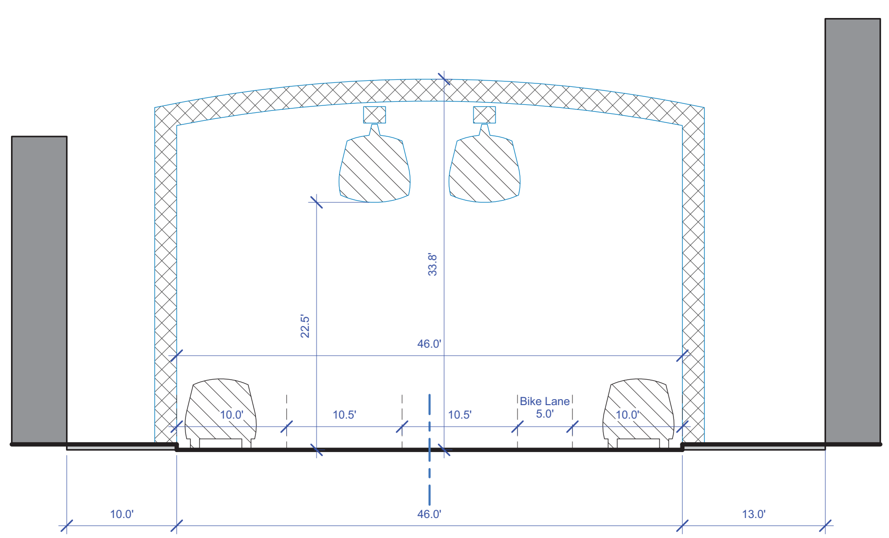
College Ave (Just south of Bool St)



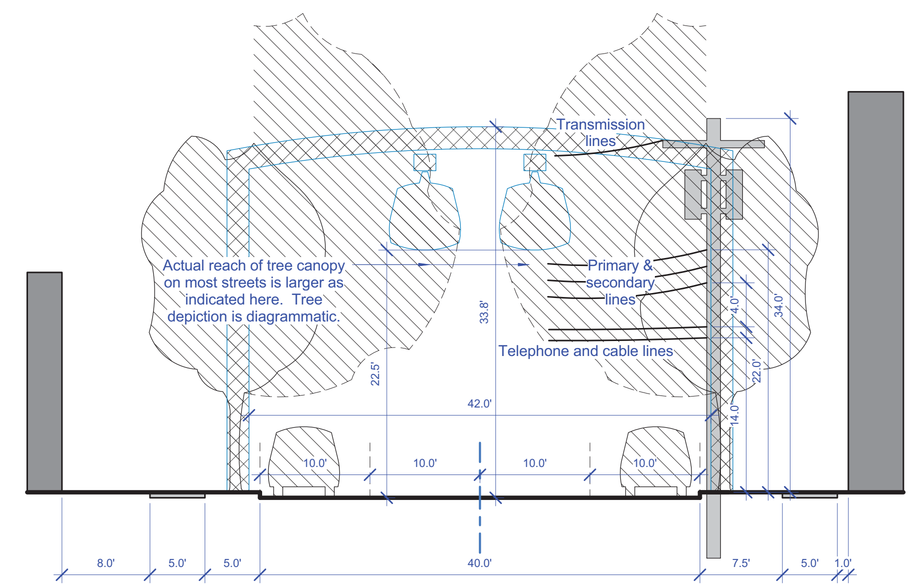
Seneca St (@ Parking garage near Aurora)



Plan Detail of PRT Pole



Green St (@ Library & City Hall)



State St (@ DSS)

8' 4' 0' 8' 16'

SCALE : 1/8" = 1'-0"

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Drawn by:	JKD
Checked by:	JKD

C3.0

Scale: 1/8" = 1'-0"

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Appendix L: TOD Analysis Assumptions

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TOD Analysis Assumptions

Commercial use mixture and parking assumptions. Since the focus of this analysis is on developing sufficient housing to support the employees of already existing workplaces in a manner that reduces both local and commuting VMTs, we have not made aggressive assumptions about the demand for *additional* retail or office space beyond that which will house business activity which is supportive of the daily life activities new residents (i.e. neighborhood groceries, cafes, news-stands, gyms, medical offices, etc). It is the provision of housing for in-commuters that will produce the most significant reduction in VMTs. To maximize space within the available zoning envelope for housing, we have assumed that only the ground floor of new development will be devoted to commercial space. Recent DIA research has indicated that a downtown resident produces 5x greater economic benefit than an additional in-commuting office worker[1], which would indicate that emphasis should be placed on housing. Additionally, the DIA concluded that in mixed-use projects built within the current zoning envelope, where the first floor was retail and the upper floors housing, only 10% of the retail space could be supported by residents' spending[2]. The remainder of the constructed retail space would need to be supported by visitors to the downtown area, the majority of whom will come by car until a competitive regional mobility alternative evolves. Given these considerations, it was assumed that no additional niche market retail was needed in Ithaca and that no second floor commercial space was necessary to serve the support needs of new residents.

Several zones have no commercial or residential parking requirement. It should be noted that this has been made possible, especially within the CBD zones, by the provision of public parking garages within walking distance, *not because a sufficient "car-free" population exists, nor because current public transit supports all visitor and commuter needs*. It will therefore be assumed that for the foreseeable future (20 year development horizon) automobiles will remain a primary means of mobility *outside* the PRT service area, and that the market viability of housing and commercial property will depend on the availability of a reasonable amount of parking. PRT however allows some of this parking to shift from "on-site" to "off-site", and by virtue of facilitating a higher density of customer base within walking distance, allows for some commercial parking to be eliminated entirely (as described for scenarios 3 and 4 below).

Because it will be impossible to determine the exact proportion and distribution of ground floor commercial uses in new development, a reasonable mixture of uses will be assumed, including restaurant, retail, offices, and services like gyms. Each type of use has its own parking requirement, so an average will be used based on the following mix of ground floor use:

For *scenarios 1&2*:

- 25% restaurant, bar, theatre, and performance venue — 1 space per 50sf net assembly space
- 25% retail — 1 space per 500sf gross floor area
- 50% office or professional service — 1 space per 250sf gross floor area
- residential upper floors — 1 space per D.U.

Per 10,000sf of floor area, this mix yields an average on-site parking requirement of 1 space per 200sf of gross floor area under current zoning requirements for commercial uses, assuming that restaurant and theatre assembly spaces average about 50% of gross floor area.

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[1] DIA Development Report, dated May 1, 2009, pp 30-34
[2] DIA Development Report, dated May 1, 2009, p44 & 49

Scenario 1 begins as a theoretical exercise to demonstrate development potential if zoning regulations are strictly followed. In 4 of the 7 zones (WEDZ-1a, B2c, B2d, and CBD-60) regulations require zero parking, therefore development area and residential unit count will be given accordingly.

However, market reality and the existing car culture will demand that parking be accommodated, thus scenario 1 will assume provision of parking in city owned garages in each zone. A further calculation of the required garage space and the number of residential units displaced will be made. It is assumed that garages will fill the zoning height envelope and that their ground floors will be commercial space. Totals for development potential in the Appendix F summary reflect the garage parking and reduced unit count, presenting a realistic scenario.

Scenario 2 examines development potential in the absence of a city investment in garages. This scenario is the same as scenario 1 in the zones which have a parking requirement (B2a, B4, SW2).

For *scenario 3*:

Commercial parking: Most of the TOD area is within a 5 minute walk+PRT journey to a structured parking facility, or location suitable for such a facility. This walk+PRT journey is equivalent to the walk time of many current downtown office workers who park in public garages in the CBD. Thus, PRT offers the opportunity to park some of the cars of *people who use the district on a **daily** basis,* predominantly the regular staff of offices, at the perimeter of the development area. In scenario 3 therefore, the on-site parking requirement for *new* offices would be reduced such that 25% of regular office workers would park off-site. In addition, 25% of office workers will be presumed to live within the PRT service area and either walk or use PRT to get to work, resulting in 50% reduction in office use parking.

As most of the new retail is expected to be of the kind serving the daily life needs of residents, (i.e. neighborhood groceries, cafes, news-stands, gyms, clothing stores, medical offices, etc) it is assumed that only 50% of retail and restaurant patrons would require parking, the remainder arriving on foot or using PRT from their homes elsewhere within the district. On-site commercial parking requirements are therefore adjusted to the following:

- 25% restaurant, bar, theatre, and performance venue — 1 space per 100sf net assembly space
- 25% retail — 1 space per 1000sf gross
- 50% office or professional service — 1 space per 500sf gross

Per 10,000sf of floor area, this mix yields an average on-site parking requirement of 1 space per 400sf of gross area, a 50% reduction in on-site commercial parking. (this is reflected in analysis spreadsheets in Appendix E as a “commercial parking factor” of 50%)

Residential parking: Scenario 3 still assumes that each household will demand parking for one auto. With the opportunity to garage autos only 5 minutes away from one’s residence, most likely with some kind of incentive to do so, such as placing a premium on the purchase of on-site parking, it will be assumed that 25% of home buyers in new developments will take this option. Therefore on-site parking for *owner occupied* dwelling units will be set at .75 per D.U. Because renters tolerate less choice with regard to parking facilities, and because the rental market in Ithaca is strong, all parking for rental units will be located off site. The assumed ratio of renters to owners is 47.4% to 52.6% respectively (see "Projected Demand for Housing" below)

On-site residential parking requirements are therefore adjusted to the following:

- owned units (52.6%) .75 space per D.U.
- rented units (47.4%) none

A calculation of the required off-site parking will be made in this scenario. The off-site total will include the following:

- Office uses: 1 space per 250sf gross office floor area. (Assumes that 25% of office workers live in the PRT use district.)
- owned residential units (52.6%) .25 space per D.U.
- rented residential units (47.4%) 1 space per D.U.

Note that in this scenario, some on-site parking is provided in all zones, including the 4 zones with no parking requirement. This prevents the amount of ground floor commercial space from approaching the theoretical 100% utilization shown in Scenario 1.

For *scenario 4*:

Scenario 4 represents a possible evolution of conditions set forth in scenario 3.

Housing & service density: As housing density and the variety of services within the PRT area increases, the district will become increasingly friendly to entirely car-free lifestyles. Studies show car use and ownership rates dropping off by about 1/3 when districts exceed a residential density of 40 people per acre[3]. Though population density in the 1050 acre PRT use district (dashed outline in figure 3, section 4) will not likely reach these levels, the population density in the 160 acre TOD area will approach 100 people per acre. Scenario 4 will assume that other mobility options and changing cultural factors will further reduce the need for on-site parking.

Connectivity: As transit connections to the greater region evolve (i.e. high speed rail, campus circulator systems, improved rural bus service, expansion of PRT network, expansion of Ithaca Carshare), entirely car-free lifestyles will be supported further, suggesting that the expansion of both on-site and off-site parking will not need to be as rapid as the expansion of housing units, and that the market viability of constructing owned units without on-site parking will increase.

In this scenario, it will be assumed that 1/3 of renting households will not own an auto and only 25% of owners will demand on-site parking. Therefore residential parking requirements will be as follows:

On-site

- owned residential units (52.6%) .25 space per D.U.
- rented residential units (47.4%) none

[3] Keith Bartholomew, "Making the Land Use, Transportation and Air Quality Connection" *PAS memo*, APA, May 1993.

Off-site

- owned residential units (52.6%) .75 space per D.U.
- rented residential units (47.4%) .66 space per D.U.

Note that in this scenario, some on-site parking is provided in all zones, including the 4 zones with no parking requirement. This prevents the amount of ground floor commercial space from approaching the theoretical 100% utilization shown in Scenario 1.

Effect of parcel assemblage. The size of a development parcel will affect to what degree setbacks reduce allowable development footprint. For the purposes of this study, the size of an average development site appropriate to each zone will be assumed for the calculation of a building setback loss factor specific to each zone (*setback reduction* in Appendix F spreadsheets). This will provide for projects similar in size to recently completed development projects, will yield buildings which can be kept within the scale of each zone's urban fabric, and be of a size that will meet a reasonable threshold of construction efficiency and financial viability.

Housing form factor. Commercial ground floor uses can be accommodated without concern for natural light assuming sufficient street frontage. However, housing floor plate utilization must take into consideration light, ventilation, view, solar access, open space, dwelling marketability and circulation access. It is also assumed that residential floors will be built above any ground level parking which is required. This allows for a determination of the maximum potential of the existing zoning envelope to be made prior to suggesting an increase in allowable building height.

Consistent with standard architectural assumptions and the assumptions used for the DIA study of downtown development, it will be assumed that 20% of a residential floor will be dedicated to circulation and mechanical spaces. (This assumption is reflected in analysis spreadsheets as an "above grade utilization factor" of 80%). The "above grade footprint" was used to determine potential number of dwelling units per floor based on an average unit size.

To determine a single reasonable average unit size for use in calculations, a unit mix was assembled which included graduate student housing, workforce housing, retiree housing, family housing, and luxury housing. (see table below). A typical interior floor area was assumed for each type of housing, as was a typical amount of "outdoor space". Including outdoor spaces like balconies or patios in the unit area creates an allowance for variable building form within the development footprint, and allows the "actual above grade footprint" to be simply divided by the average floor area per dwelling to obtain a reasonable dwelling unit count in any given zone. A figure of 1500sf per dwelling unit was used consistently.

Table # Residential unit mixture

Residential Unit Scenarios						
Scenario	Weighted SF	Unit Mix	Total SF	Unit Size	Private Outdoor Space	
Graduate student housing	170	20%	850	800	50	5'x10' patio
Workforce housing	212.5	25%	850	800	50	5'x10' patio
Retiree housing	325	25%	1300	1200	100	10'x10' patio
Single-family housing	650	25%	2600	2000	600	20'x30' patio
Luxury housing	155	5%	3100	2500	600	20'x30' patio
Totals:	1512.5	100%				
Approximate Average Unit Size:	1500	SF				

In addition, a figure of 2.2 persons per dwelling unit was used to determine potential non-student population[4].

Projected demand for housing. An assessment of 20 year projected demand for urban-style housing was generated to compare with the development potential within the TOD area. This demand is based on documented trends and does not take into account any population shifts or changes in housing preference due to catastrophic economic conditions, energy price escalations or climate change. The demand figures include a one time relocation of existing in-commuters to locations within the TOD area served by transit, a portion of the projected overall housing demand for the County, and all of the projected off campus student housing demand.

- *In-commuter relocation:* Tompkins County has an employee population of 57,032[5] and a commuter population (those using the automobile to get to work) of 41,063, or 72% of the workforce[6]. Based on data from the Tompkins County/Cornell University Employee Commuter Survey Report of February 2006, which is taken to be an average sampling of commuters in Tompkins County, 30% indicated that they would relocate closer to employment centers if affordable housing was available. The survey also explored the type of housing respondents would "be interested in" if they relocated, and allowed for *multiple responses* with regard to housing type. Of these commuters, 80% expressed an "interest in" a single family home, 14.1% apartment, 10.3 duplex, 7.1 condominium, 3% mobile home or trailer park. Other choices could be viewed predominantly as a subset of the single family home (rural 10+acres and luxury estate 5+acres). [7]

  It is expected that apartment, condominium, and duplex housing types will be developed within the TOD area under consideration, however the percentages of interest from the TC/Cornell study likely overlap and cannot be simply added. Therefore, for purposes of arriving at a conservative figure for the number of commuters likely to choose a housing type other than single family, it has been assumed that since the single family home is culturally the preferred housing option, that those indicating interest in this choice also prefer it to other choices, if its affordable. As a result of this assumption, a figure of 20% of the commuter population is considered to be willing to relocate into housing types offered within the TOD area. Extending this TC/Cornell sample over the entire commuter population of 41,063, 12,318 would be willing to relocate and **2,464** would be interested in living in the TOD area based on housing preference. It is assumed that this will be the number of households, therefore assuming the average of 2.2 persons per household this equates to **5,421** residents.

[4] US Census data for zip code 14850
[5] ITCTC2025 Long Range Transportation Plan
[6] Tompkins County Comprehensive Plan, p.18
[7] Tompkins County/Cornell University Employee Commuter Survey report, chart A, p.11

- *Projected overall housing demand:* The Tompkins County Affordable Housing Needs Assessment dated August 2006 concluded that county-wide housing demand, *excluding student demand and not considering the needs of relocating in-commuters*, from 2006 – 2014 would be 3023 units (378 units per year), of which 54% (204 units per year) need to be affordable for households below 80% of median income[8]. Because affordability can be enhanced by locating housing closer to workplaces thus reducing the percentage of household income used on transportation, and because the more compact housing types proposed for the TOD area can be made more readily affordable than single family homes, and because the majority of the Tompkins County employment base is within the City of Ithaca and the Universities, it will be assumed that 50% the projected need for affordable units (102 units per year) will be accommodated in the TOD area. This is consistent with recommendations from County Planning, which has recommended building 1000 units of affordable housing inside the City limits in the next 10 years (100 units per year)[9]. Furthermore, the projected demand for affordable units was suggested to be 40% owner occupied and 60% rental. However because the city is actively promoting home ownership, this study will assume a 50/50 mix of rented/owned (51 rented/51 owned per year).

  Additionally, 20% of the remainder of projected demand (35 units per year for the higher income ranges) will be assumed to be placed in the TOD area, based on housing type preferences discussed in the above section. Of demand in this price range, it was suggested that 42% be rental and 57% be owner occupied. This study will assume a 40/60 mix of rented/owned. (14 rented/21 owned per year)[10]

  This results in a total projected demand within the TOD area of 137 units per year (65 rented/ 72 owned), or **2,740** units over the 20 year development horizon with 47.4% rented and 52.6% owned . At 2.2 persons per household, this equates to **6,028** residents.

  Off campus student housing demand: Cornell University has a student population of 19,800 and Ithaca College, 6,500.[11] Of these student populations, fully 50% of Cornell (9,900) and 30% of IC (1,950) live off campus in approximately 4,000 housing units[12]. This yields an average student household size of 2.86 persons per household. 4,000 units represent roughly 20% of all rental housing in Tompkins County. The projected demand for rental housing between 2005 and 2008 was estimated to be 450 units[13], of which 20% (90 units over 3 years, or 30 per year) would be expected to serve student demand. Using this figure as a baseline and asserting that student rentals need to be located conveniently in relation to the academic institutions (as is reflected in the current development pressure on the Collegetown neighborhood), 60% of this demand (18 units per year) will be assumed to fall within the TOD area.

  Total anticipated student housing demand within the TOD area, over the 20 year development horizon, will therefore be **360** units housing **1,030** residents.

Overall anticipated housing demand is therefore projected to be **2,464** units for relocating in-commuters, **2,740** units of overall demand, and **360** units of student housing, for a total of **5,564** units and an additional resident population of **12,479** persons.

Table #: Projected housing demand

Projected 20 year housing demand		
Type of demand	**# of Units**	**# of Residents**
In-commuter relocation	2,464	5,421
Non-student demand	2,740	6,028
Off campus student housing	360	1,030
Total	5,564	12,479

8 The Tompkins County Affordable Housing Needs Assessment, table 7, p.9
9 Tompkins County Housing Strategy.doc
10 all rental vs owner numbers derived from data in The Tompkins County Affordable Housing Needs Assessment, table 7, p.9
11 University admissions websites
12 U. S. Housing and Urban Development Analysis of the Ithaca NY Housing Market, dated January 1, 2005, p.7
13 U. S. Housing and Urban Development Analysis of the Ithaca NY Housing Market, dated January 1, 2005, p.8

Appendix M: Development Potential

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TOD Analysis Summary

WEDZ-1a								
Development Potential	**% developed**	**Scenario #1**	**% developed**	**Scenario #2**	**% developed**	**Scenario #3**	**% developed**	**Scenario #4**
Retail	25%	44247 SF	25%	16814 SF	25%	21681 SF	50%	47655 SF
Restaurant/ Assembly	25%	44247 SF	25%	16814 SF	25%	21681 SF	50%	47655 SF
Office	25%	88495 SF	25%	33628 SF	25%	43363 SF	50%	95309 SF
Office workers	25%	265	25%	101	25%	130	50%	286
Dwelling Units	25%	*378*	25%	94	25%	378	50%	1510
Residents	25%	*847*	25%	212	25%	847	50%	3388
On-site Parking	25%	NA	25%	431	25%	366	50%	675
Off-site Parking	25%	NA	25%	NA	25%	272	50%	1164
Scenario #1 with public garage parking accomodation								
Garage Parking	25%	1088	-	-	-	-	-	-
Dwelling Units	25%	203	-	-	-	-	-	-
Residents	25%	456	-	-	-	-	-	-
B-2c								
Development Potential	**% developed**	**Scenario #1**	**% developed**	**Scenario #2**	**% developed**	**Scenario #3**	**% developed**	**Scenario #4**
Retail	25%	22963 SF	25%	9989 SF	25%	13089 SF	50%	28360 SF
Restaurant/ Assembly	25%	22963 SF	25%	9989 SF	25%	13089 SF	50%	28360 SF
Office	25%	45927 SF	25%	19978 SF	25%	26178 SF	50%	56719 SF
Office workers	25%	138	25%	60	25%	79	50%	170
Dwelling Units	25%	*196*	25%	49	25%	196	50%	784
Residents	25%	*440*	25%	110	25%	440	50%	1758
On-site Parking	25%	NA	25%	249	25%	208	50%	387
Off-site Parking	25%	NA	25%	NA	25%	145	50%	611
Scenario #1 with public garage parking accomodation								
Garage Parking	25%	565	-	-	-	-	-	-
Dwelling Units	25%	106	-	-	-	-	-	-
Residents	25%	237	-	-	-	-	-	-
B-2d								
Development Potential	**% developed**	**Scenario #1**	**% developed**	**Scenario #2**	**% developed**	**Scenario #3**	**% developed**	**Scenario #4**
Retail	25%	16800 SF	25%	8148 SF	25%	11256 SF	50%	23856 SF
Restaurant/ Assembly	25%	16800 SF	25%	8148 SF	25%	11256 SF	50%	23856 SF
Office	25%	33600 SF	25%	16296 SF	25%	22512 SF	50%	47712 SF
Office workers	25%	101	25%	49	25%	68	50%	143
Dwelling Units	25%	*108*	25%	36	25%	108	50%	430
Residents	25%	*241*	25%	80	25%	241	50%	965
On-site Parking	25%	NA	25%	199	25%	155	50%	295
Off-site Parking	25%	NA	25%	NA	25%	88	50%	352
Scenario #1 with public garage parking accomodation								
Garage Parking	25%	382	-	-	-	-	-	-
Dwelling Units	25%	46	-	-	-	-	-	-
Residents	25%	104	-	-	-	-	-	-

CBD-60+								
Development Potential	**% developed**	**Scenario #1**	**% developed**	**Scenario #2**	**% developed**	**Scenario #3**	**% developed**	**Scenario #4**
Retail	25%	15950 SF	25%	5902 SF	25%	5902 SF	50%	15950 SF
Restaurant/ Assembly	25%	15950 SF	25%	5902 SF	25%	5902 SF	50%	15950 SF
Office	25%	31900 SF	25%	11803 SF	25%	11803 SF	50%	31900 SF
Office workers	25%	96	25%	35	25%	35	50%	96
Dwelling Units	25%	*238*	25%	34	25%	238	50%	681
Residents	25%	*534*	25%	76	25%	534	50%	1526
On-site Parking	25%	NA	25%	152	25%	153	50%	249
Off-site Parking	25%	NA	25%	NA	25%	156	50%	513
Scenario #1 with public garage parking accomodation								
Garage Parking	25%	480	-	-	-	-	-	-
Dwelling Units	25%	161	-	-	-	-	-	-
Residents	25%	362	-	-	-	-	-	-
SW-2								
Development Potential	**% developed**	**Scenario #1**	**% developed**	**Scenario #2**	**% developed**	**Scenario #3**	**% developed**	**Scenario #4**
Retail	25%	18897 SF	25%	18897 SF	25%	37332 SF	50%	78813 SF
Restaurant/ Assembly	25%	18897 SF	25%	18897 SF	25%	37332 SF	50%	78813 SF
Office	25%	37793 SF	25%	37793 SF	25%	74665 SF	50%	157625 SF
Office workers	25%	113	25%	113	25%	224	50%	473
Dwelling Units	25%	393	25%	393	25%	393	50%	1573
Residents	25%	882	25%	882	25%	882	50%	3529
On-site Parking	25%	771	25%	771	25%	528	50%	995
Off-site Parking	25%	NA	25%	NA	25%	313	50%	1270
B-2a								
Development Potential	**% developed**	**Scenario #1**	**% developed**	**Scenario #2**	**% developed**	**Scenario #3**	**% developed**	**Scenario #4**
Retail	25%	3160 SF	25%	3160 SF	25%	6321 SF	50%	13168 SF
Restaurant/ Assembly	25%	3160 SF	25%	3160 SF	25%	6321 SF	50%	13168 SF
Office	25%	6321 SF	25%	6321 SF	25%	12642 SF	50%	26337 SF
Office workers	25%	19	25%	19	25%	38	50%	79
Dwelling Units	25%	70	25%	70	25%	70	50%	281
Residents	25%	158	25%	158	25%	158	50%	630
On-site Parking	25%	133	25%	133	25%	91	50%	169
Off-site Parking	25%	NA	25%	NA	25%	55	50%	225
B-4								
Development Potential	**% developed**	**Scenario #1**	**% developed**	**Scenario #2**	**% developed**	**Scenario #3**	**% developed**	**Scenario #4**
Retail	25%	5823 SF	25%	5823 SF	25%	9546 SF	50%	19092 SF
Restaurant/ Assembly	25%	5823 SF	25%	5823 SF	25%	9546 SF	50%	19092 SF
Office	25%	11646 SF	25%	11646 SF	25%	19092 SF	50%	38184 SF
Office workers	25%	35	25%	35	25%	57	50%	115
Dwelling Units	25%	61	25%	61	25%	61	50%	244
Residents	25%	137	25%	137	25%	137	50%	548
On-site Parking	25%	178	25%	178	25%	120	50%	223
Off-site Parking	25%	NA	25%	NA	25%	56	50%	211

TOTALS:								
Dwelling Unit and resident totals assume Scenario #1 with public garage parking								
Development Potential		**Scenario #1**		**Scenario #2**		**Scenario #3**		**Scenario #4**
Retail		127841 SF		68733 SF		105127 SF		226893 SF
Restaurant/ Assembly		127841 SF		68733 SF		105127 SF		226893 SF
Office		255682 SF		137465 SF		210254 SF		453787 SF
Office workers		767		412		631		1361
Dwelling Units		1041		738		1444		5503
Residents		2336		1655		3239		12344
On-site Parking		1082		2113		1621		2993
Off-site Parking		NA		NA		1085		4346
Public garage parking		2516		NA		NA		NA

	Light green fields feed corresponding fields on each zone analysis tab			
# of Residents per dwelling unit	2.243			
Tompkins County percentage of renters	47.40%			
Tompkins County percentage of owners	52.60%			

Redevelopment Areas in PRT Impact Zone

			Subtracted Buildings	PRT Impact Area
B-2a	421,387	SF	50%	210,694
B-2c	480,500	SF	21,659	458,841
B-2d	395,030	SF	27,368	367,662
B-4	305,471	SF	0	305,471
SW-2	1,512,752	SF	283,705	1,229,047
WEDZ-1a	840,000	SF	53,378	786,622
CBD-60 Plus	1,386,962	SF	20%	277,392
WEDZ-1b	71,500	SF		71,500

Development Analysis WEDZ-1a:

Zoning Requirements:					
Off-Street Parking Requirement	None				
Off-Street Loading Requirement	None				
Minimum Lot Size					
Area (sq ft)	3000				
Width at Street Line (ft)	30				
Max Building Height:					
Number of Stories	5 max; 2 min				
Height in Feet	12' min. for 1st story measured from grade, 12' for each add'l story with an add'l 5' for cornice				
Maximum Lot Coverage (%) by Buildings	100% for parcels 50' or less wide; 90% for parcels with 3 or more boundaries greater than 50' wide; Except as required for provision of 15' min/ 20' max curb setback and required rear yard and required buffer where commercial zone abuts residential zone and required accommodation of pedestrian ways and protection of view corridors designated in the West End Urban Design Plan 1999 (See Section 325-4)				
Yard Dimensions					
Front	None				
Side	None				
Side	None				
Rear	10' Min.				
Minimum Building Height	2 stories or 24' (See Section 325-3B)				
PRT Impact Area	786,622	~2-3 minute walk (~750') from PRT within non-residential zones			
		Includes subtracted buildings			
Zoning Setback Reduction Analysis					
Hypothetical assembled redevelopment lot	45000				
Lot size after setbacks are applied	43500				
Setback Reduction %:	**3.33%**				
FIELD KEY					
Calculated Value					
Value from Base Data					
Adjustable Input Value					

Scenario #1 - Theoretical Development Potential Per Current Zoning

Redevelopment Area (SF)	786,622	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**786,622**	**SF**			
Maximum lot coverage	90%	*Curb setback covered by this requirement*			
Allowable Development Footprint	**707,960**	**SF**			
Maximum Building Stories	5		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	100.00%		Assumes development feasibilty relies on off-site parking		
Actual Commercial Footprint (per GFUF)	707,960	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**707,960**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	566,368				
# of Office Stories	0				
# of Residential Stories	4				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**2,265,471**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**1510**	Assume 2.243 residents per unit			
			2.243	**3388**	Total Residents
			47.40%	**1606**	Total Renters
			52.60%	**1782**	Total Owners
Parking Factors (Per typical zoning factors):					
Note: The following is a calculation of parking which would be required to meet typical market expectations despite zoning allowance for zero parking. *It is assumed that viable commercial development will rely on the provision of off-street parking or parking garages independent of any zoning allowance for no parking.*					
Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			

Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	176,990	25%	354		
Restaurant/ Theater/ Assembly	176,990	25%	1770	Assumes 50% net SF is assembly	
Office	353,980	50%	1416	75%	**equals 1062 office workers**
Total:	**707,960**	**Total:**	**3540**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	3540	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	100%				
On-site commercial parking spaces	3540				
# of Residential Parking Spaces	1510	Equal to number of housing units. Assumes 1 space per unit.			
Residential Parking Factor	100%				
On-site residential parking spaces	1510				
Total On-site Parking:	**5050**				
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	**0**	SF	**This value set to zoning allowance for no parking**		
% of Lot Required by Parking:	**0%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Ground Floor Lot Coverage	**90%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**90%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**100%**	Based on Allowable Development Footprint			
Development Potential	**500%**	Based on Allowable Development Footprint			
Conclusion: This scenario is realistic under current market conditions only if garage parking is provided. Provision of garage parking (with ground floor retail) would result in the loss of 696 units (see calculation below). See scenario 2 for development potential if on-site parking is provided. See scenario 3 for development potential if off-site parking with transit circulator is provided.					
Gross above grade space (SF)	2,831,839				
Commercial parking space requirement (SF)	(1,061,940)				
Space left on above grade stories for residential parking and dwelling units (SF)	1,769,900				
Residential parking space requirement (SF)	244,124				
# of residential parking spaces	814				
# of residential units	814	Assume 2.243 residents per unit			
			2.243	**1825**	Total Residents
			47.40%	**865**	Total Renters
			52.60%	**960**	Total Owners
Total public garage spaces	4,354				

Scenario #2 - Actual Development Potential Tempered by Market Demands for Parking

Redevelopment Area (SF)	786,622	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**786,622**	**SF**			
Maximum lot coverage	90%	*Curb setback covered by this requirement*			
Allowable Development Footprint	**707,960**	**SF**			
Maximum Building Stories	2		**Limited by development reality**		
Ground Floor Utilization Factor (GFUF)	38.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	269,025	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**269,025**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	566,368				
# of Office Stories	0				
# of Residential Stories	1				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**566,368**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**378**	Assume 2.243 residents per unit			
			2.243	**847**	Total Residents
			47.40%	**401**	Total Renters
			52.60%	**445**	Total Owners
Parking Factors (Per typical zoning factors):					
Note: The following is a calculation of parking which would be provided on-site to meet current market expectations, despite zoning allowance for zero parking.					
Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			
Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	67,256	25%	135		
Restaurant/ Theater/ Assembly	67,256	25%	673	Assumes 50% net SF is assembly	
Office	134,512	50%	538	75%	**equals 404 office workers**

Total:	**269,025**	**Total:**	**1345**
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**	
Parking Requirement:			
# of Commercial Parking Spaces	1345	Derived from Parking Mix Factor & Calculated Commercial SF	
Commercial Parking Factor	100%		
On-site commercial parking spaces	1345		
# of Residential Parking Spaces	378	Equal to number of housing units. Assumes 1 space per unit.	
Residential Parking Factor	100%		
On-site residential parking spaces	378		
Total On-site Parking:	**1723**		
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking	
Area per Parking Space	300		
Total Parking Footprint:	516,811	SF	
% of Lot Required by Parking:	**66%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)	
% of Ground Floor Lot Coverage	**34%**	Actual Commercial Footprint/ Redevelopment Lot Size	
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**	
Ground Floor Utilization	**38%**	Based on Allowable Development Footprint	
Development Potential	**138%**	Based on Allowable Development Footprint	
Conclusion: Meeting real world parking requirements results in very little housing, unrealized zoning height allowance, and a loss of ~62% of ground floor commercial development potential versus scenario 1.			

Scenario #3 - Development Potential Per Current Zoning with PRT

Redevelopment Area (SF)	786,622	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**786,622**	**SF**			
Maximum lot coverage	90%	*Curb setback covered by this requirement*			
Allowable Development Footprint	**707,960**	**SF**			
Maximum Building Stories	5		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	49.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	346,900	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**346,900**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	566,368				
# of Office Stories	0				
# of Residential Stories	4				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**2,265,471**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**1510**	Assume 2.243 residents per unit			
			2.243	**3388**	Total Residents
			47.40%	**1606**	Total Renters
			52.60%	**1782**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	86,725	25%	173		
Restaurant/ Theater/ Assembly	86,725	25%	867	Assumes 50% net SF is assembly	
Office	173,450	50%	694	75%	**equals 520 office workers**
Total:	**346,900**	**Total:**	**1735**		

M - 12

Retail-Restaurant-Office Parking Mix	1 per 200	SF of gross building area			
Parking Requirement:					
# of Commercial Parking Spaces	1735	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	50%				
On-site commercial parking spaces	867				
# of Owner-occupied Parking Spaces	794	Assumes all renter parking is off-site.			
Residential Parking Factor	75%				
On-site residential parking spaces	596				
Total On-site Parking:	**1463**	**Offsite Need:**		**1088**	
		Office Parking		**173**	**25% of office spaces**
		Owner Parking		**199**	**Balance of owner-occupied not on-site**
		Renter Parking		**716**	**100% of renter parking**
Parking Demand Ratio	**78.6%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	438,921	SF			
% of Lot Required by Parking:	**56%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Lot Covered by Building:	**44%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**49%**	Based on Allowable Development Footprint			
Development Potential	**449%**	Based on Allowable Development Footprint			
Conclusion: Residential development potential is only limited by off-site parking accommodation. Ground floor commercial development realized is 49% of zoning potential while providing market-required on-site parking, making development more economically feasible. Higher density of residential development also results in a lower overall amount of parking required, because of the creation of a district sufficiently dense to support walk and transit mobility modes (approx..40ppl/ac). Off-site parking increases GF commercial space and allows street space to be more pedestrian friendly, even though there is no increase in housing density over scenario 1					

M - 13

Scenario #4 - Development Potential of Expanded Zoning Envelope

Redevelopment Area (SF)	786,622	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**786,622**	**SF**			
Maximum lot coverage	90%	*Curb setback covered by this requirement*			
Allowable Development Footprint	**707,960**	**SF**			
Maximum Building Stories	9				
Ground Floor Utilization Factor (GFUF)	53.85%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	381,236	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**381,236**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	566,368				
# of Office Stories	0				
# of Residential Stories	8				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**4,530,943**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**3021**	Assume 2.243 residents per unit			
			2.243	**6775**	Total Residents
			47.40%	**3211**	Total Renters
			52.60%	**3564**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	95,309	25%	191		
Restaurant/ Theater/ Assembly	95,309	25%	953	Assumes 50% net SF is assembly	
Office	190,618	50%	762	75%	**equals 572 office workers**
Total:	**381,236**	**Total:**	**1906**		

Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	1906	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Reduction Factor	50%				
On-site commercial parking spaces	953				
# of Owner-occupied Parking Spaces	1589	Assumes all renter parking is off-site.			
Residential Parking Factor	25%				
On-site residential parking spaces	397				
Total On-site Parking:	**1350**	**Offsite Need:**		**2327**	
		Office Parking		**191**	**25% of office spaces**
		Owner Parking		**1192**	**Balance of owner-occupied not on-site**
		Renter Parking		**945**	**Two thirds of renter parking**
Parking Demand Ratio	**74.6%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	405,091	SF			
% of Lot Required by Parking:	**51%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks			
% of Lot Covered by Building:	**48%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**54%**	Based on Allowable Development Footprint			
Development Potential	**854%**	Based on Allowable Development Footprint			

Conclusion: Residential development potential is only limited by off-site parking accommodation and reasonable building height. Commercial development realized is 54% of zoning potential while providing market-required parking. Increase in housing density further reduces overall demand for both on and off site parking because of the increasing walk/transit friendliness of the district.

Development Analysis B-2c:

Zoning Requirements:		
Off-Street Parking Requirement	None	
Off-Street Loading Requirement	None	
Minimum Lot Size		
Area (sq ft)	None	
Width at Street Line (ft)	25	
Max Building Height:		
Number of Stories	None	
Height in Feet	50	
Maximum Lot Coverage (%) by Buildings	85% except as required for rear yard, or side yard.	
Yard Dimensions		
Front	None	
Side	10'	
Side	5'	
Rear	15% or 20'	
Minimum Building Height	25'	
PRT Impact Area	458,841	~2-3 minute walk (~750') from PRT within non-residential zones
		Includes subtracted buildings
Zoning Setback Reduction Analysis		
Hypothetical assembled redevelopment lot	33750	
Lot size after setbacks are applied	27025	
Setback Reduction %:	**19.9%**	
FIELD KEY		
Calculated Value		
Value from Base Data		
Adjustable Input Value		

Scenario #1 - Theoretical Development Potential Per Current Zoning

Redevelopment Area (SF)	458,841	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	19.9%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**367,413**	**SF**			
Maximum lot coverage	100%	*85% max/ zoning but Setback Reduction satisfies requirement*			
Allowable Development Footprint	**367,413**	**SF**			
Maximum Building Stories	5		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	100.00%		Assumes development feasibilty relies on off-site parking		
Actual Commercial Footprint (per GFUF)	367,413	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**367,413**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	293,930				
# of Office Stories	0				
# of Residential Stories	4				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**1,175,721**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**784**	Assume 2.243 residents per unit			
			2.243	**1758**	Total Residents
			47.40%	**833**	Total Renters
			52.60%	**925**	Total Owners
Parking Factors (Per typical zoning factors):					

Note: The following is a calculation of parking which would be required to meet typical market expectations despite zoning allowance for zero parking. *It is assumed that viable commercial development will rely on the provision of off-street parking or parking garages independent of any zoning*

Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			
Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	91,853	25%	184		
Restaurant/ Theater/ Assembly	91,853	25%	919	Assumes 50% net SF is assembly	
Office	183,706	50%	735	75%	**equals 551 office workers**
Total:	**367,413**	**Total:**	**1837**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	1837	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	100%				
On-site commercial parking spaces	1837				
# of Residential Parking Spaces	784	Equal to number of housing units. Assumes 1 space per unit.			
Residential Parking Factor	100%				
On-site residential parking spaces	784				
Total On-site Parking:	**2621**				
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	**0**	SF	**This value set to zoning allowance for no parking**		
% of Lot Required by Parking:	**0%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Ground Floor Lot Coverage	**80%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**80%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**100%**	Based on Allowable Development Footprint			
Development Potential	**500%**	Based on Allowable Development Footprint			
Conclusion: This scenario is realistic under current market conditions only if garage parking is provided. Provision of garage parking (with ground floor retail) would result in the loss of 362 units. See scenario 2 for development potential if on-site parking is provided. See scenario 3 for development potential if off-site parking with transit circulator is provided.					
Gross above grade space (SF)	1,469,651				
Commercial parking space requirement (SF)	(551,119)				
Space left on above grade stories for residential parking and dwelling units (SF)	918,532				
Residential parking space requirement (SF)	126,694				
# of residential parking spaces	422				
# of residential units	422	Assume 2.243 residents per unit			
			2.243	**947**	Total Residents
			47.40%	**449**	Total Renters
			52.60%	**498**	Total Owners
Total public garage spaces	2,259				

Scenario #2 - Actual Development Potential Tempered by Market Demands for Parking

Redevelopment Area (SF)	458,841	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	20%	*0*			
Redevelopment Area (SF) with Setback Reduction	**367,413**	**SF**			
Maximum lot coverage	100%	*0*			
Allowable Development Footprint	**367,413**	**SF**			
Maximum Building Stories	2		**Limited by development reality**		
Ground Floor Utilization Factor (GFUF)	43.50%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	159,825	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**159,825**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	293,930				
# of Office Stories	0				
# of Residential Stories	1				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**293,930**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**196**	Assume 2.243 residents per unit			
			2.243	**440**	Total Residents
			47.40%	**208**	Total Renters
			52.60%	**231**	Total Owners
Parking Factors (Per typical zoning factors):					

Note: The following is a calculation of parking which would be provided on-site to meet current market expectations, despite zoning allowance for zero parking.

Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			
Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	39,956	25%	80		
Restaurant/ Theater/ Assembly	39,956	25%	400	Assumes 50% net SF is assembly	
Office	79,912	50%	320	75%	**equals 240 office workers**
Total:	**159,825**	**Total:**	**799**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	799	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	100%				
On-site commercial parking spaces	799				
# of Residential Parking Spaces	196	Equal to number of housing units. Assumes 1 space per unit.			
Residential Parking Factor	100%				
On-site residential parking spaces	196				
Total On-site Parking:	**995**				
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	298,523	SF			
% of Lot Required by Parking:	**65%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Ground Floor Lot Coverage	**35%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**44%**	Based on Allowable Development Footprint			
Development Potential	**144%**	Based on Allowable Development Footprint			
Conclusion: Meeting real world parking requirements results in very little housing, unrealized zoning height allowance, and a loss of ~56% of ground floor commercial development potential versus scenario 1.					

Scenario #3 - Development Potential Per Current Zoning with PRT

Redevelopment Area (SF)	458,841	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	19.9%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**367,413**	**SF**			
Maximum lot coverage	100%	*85% max/ zoning but Setback Reduction satisfies requirement*			
Allowable Development Footprint	**367,413**	**SF**			
Maximum Building Stories	5		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	57.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	209,425	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**209,425**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	293,930				
# of Office Stories	0				
# of Residential Stories	4				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**1,175,721**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**784**	Assume 2.243 residents per unit			
			2.243	**1758**	Total Residents
			47.40%	**833**	Total Renters
			52.60%	**925**	Total Owners
Parking Factors (Per typical zoning factors):					

Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	52,356	25%	105		
Restaurant/ Theater/ Assembly	52,356	25%	524	Assumes 50% net SF is assembly	
Office	104,713	50%	419	75%	**equals 314 office workers**
Total:	**209,425**	**Total:**	**1047**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	1047	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	50%				
On-site commercial parking spaces	524				
# of Owner-occupied Parking Spaces	412	Assumes all renter parking is off-site.			
Residential Parking Factor	75%				
On-site residential parking spaces	309				
Total On-site Parking:	**833**	**Offsite Need:**		**579**	
		Office Parking		**105**	**25% of office spaces**
		Owner Parking		**103**	**Balance of owner-occupied not on-site**
		Renter Parking		**372**	**100% of renter parking**
Parking Demand Ratio	**77.1%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	249,833	SF			
% of Lot Required by Parking:	**54%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Lot Covered by Building:	**46%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**57%**	Based on Allowable Development Footprint			
Development Potential	**457%**	Based on Allowable Development Footprint			
Conclusion: Residential development potential is only limited by off-site parking accommodation. Ground floor commercial development realized is 57% of zoning potential while providing market-required on-site parking, making development more economically feasible. Higher density of residential development also results in a lower overall amount of parking required, because of the creation of a district sufficiently dense to support walk and transit mobility modes (approx..40ppl/ac). Off-site parking increases GF commercial space and allows street space to be more pedestrian friendly, even though there is no increase in housing density over scenario 1					

Scenario #4 - Development Potential of Expanded Zoning Envelope

Redevelopment Area (SF)	458,841	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	19.9%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**367,413**	**SF**			
Maximum lot coverage	100%	*85% max/ zoning but Setback Reduction satisfies requirement*			
Allowable Development Footprint	**367,413**	**SF**			
Maximum Building Stories	9				
Ground Floor Utilization Factor (GFUF)	61.75%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	226,877	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**226,877**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	293,930				
# of Office Stories	0				
# of Residential Stories	8				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**2,351,441**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**1568**	Assume 2.243 residents per unit			
			2.243	**3516**	Total Residents
			47.40%	**1667**	Total Renters
			52.60%	**1850**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	56,719	25%	113		
Restaurant/ Theater/ Assembly	56,719	25%	567	Assumes 50% net SF is assembly	
Office	113,439	50%	454	75%	**equals 340 office workers**
Total:	**226,877**	**Total:**	**1134**		

Retail-Restaurant-Office Parking Mix	1 per 200	SF of gross building area		
Parking Requirement:				
# of Commercial Parking Spaces	1134	Derived from Parking Mix Factor & Calculated Commercial SF		
Commercial Parking Reduction Factor	50%			
On-site commercial parking spaces	567			
# of Owner-occupied Parking Spaces	825	Assumes all renter parking is off-site.		
Residential Parking Factor	25%			
On-site residential parking spaces	206			
Total On-site Parking:	**773**	**Offsite Need:**	**1222**	
		Office Parking	**113**	**25% of office spaces**
		Owner Parking	**618**	**Balance of owner-occupied not on-site**
		Renter Parking	**490**	**Two thirds of renter parking**
Parking Demand Ratio	**73.9%**	On & off-site parking accommodation compared to total calculated parking		
Area per Parking Space	300			
Total Parking Footprint:	232,001	SF		
% of Lot Required by Parking:	**51%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks		
% of Lot Covered by Building:	**49%**	Actual Commercial Footprint/ Redevelopment Lot Size		
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**		
Ground Floor Utilization	**62%**	Based on Allowable Development Footprint		
Development Potential	**862%**	Based on Allowable Development Footprint		

Conclusion: Residential development potential is only limited by off-site parking accommodation and reasonable building height. Commercial development realized is 62% of zoning potential while providing market-required parking. Increase in housing density further reduces overall demand for both on and off site parking because of the increasing walk/transit friendliness of the district.

Development Analysis B-2d:

Zoning Requirements:		
Off-Street Parking Requirement	Same as B-2a except that	
Off-Street Loading Requirement	Provide per zoning	
Minimum Lot Size		
Area (sq ft)	3000	
Width at Street Line (ft)	40	
Max Building Height:		
Number of Stories	4	
Height in Feet	40	
Maximum Lot Coverage (%) by Buildings	75%	
Yard Dimensions		
Front	10	
Side	10	
Side	5	
Rear	15% or 20'	
Minimum Building Height	25'	
PRT Impact Area	367,662	~2-3 minute walk (~750') from PRT within non-residential zones
		Includes subtracted buildings
Zoning Setback Reduction Analysis		
Hypothetical assembled redevelopment lot	33750	
Lot size after setbacks are applied	24675	
Setback Reduction %:	**26.9%**	
FIELD KEY		
Calculated Value		
Value from Base Data		
Adjustable Input Value		

Scenario #1 - Theoretical Development Potential Per Current Zoning

Redevelopment Area (SF)	367,662	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	26.9%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**268,802**	**SF**			
Maximum lot coverage	100%	*75% max/ zoning but Setback Reduction satisfies requirement*			
Allowable Development Footprint	**268,802**	**SF**			
Maximum Building Stories	4		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	100.00%		Assumes development feasibilty relies on off-site parking		
Actual Commercial Footprint (per GFUF)	268,802	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**268,802**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	215,041				
# of Office Stories	0				
# of Residential Stories	3				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**645,124**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**430**	Assume 2.243 residents per unit			
			2.243	**965**	Total Residents
			47.40%	**457**	Total Renters
			52.60%	**507**	Total Owners
Parking Factors (Per typical zoning factors):					
Note: The following is a calculation of parking which would be required to meet typical market expectations despite zoning allowance for zero parking. *It is assumed that viable commercial development will rely on the provision of off-street parking or parking garages independent of any zoning*					
Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			
Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			

Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	67,200	25%	134		
Restaurant/ Theater/ Assembly	67,200	25%	672	Assumes 50% net SF is assembly	
Office	134,401	50%	538	75%	**equals 403 office workers**
Total:	**268,802**	**Total:**	**1344**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	1344	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	100%				
On-site commercial parking spaces	1344				
# of Residential Parking Spaces	430	Equal to number of housing units. Assumes 1 space per unit.			
Residential Parking Factor	100%				
On-site residential parking spaces	430				
Total On-site Parking:	**1774**				
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	**0**	SF	**Value set to zero based on the assumption that any new development**		
% of Lot Required by Parking:	**0%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Ground Floor Lot Coverage	**73%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**73%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**100%**	Based on Allowable Development Footprint			
Development Potential	**400%**	Based on Allowable Development Footprint			
Conclusion: This scenario is realistic under current market conditions only if garage parking is provided. Provision of garage parking (with ground floor retail) would result in the loss of 284 units. See scenario 2 for development potential if on-site parking is provided. See scenario 3 for development potential if off-site parking with transit circulator is provided.					
Gross above grade space (SF)	806,405				
Commercial parking space requirement (SF)	(403,203)				
Space left on above grade stories for residential parking and dwelling units (SF)	403,203				
Residential parking space requirement (SF)	55,614				
# of residential parking spaces	185				
# of residential units	185	Assume 2.243 residents per unit			
			2.243	**416**	Total Residents
			47.40%	**197**	Total Renters
			52.60%	**219**	Total Owners
Total public garage spaces	1,529				

Scenario #2 - Actual Development Potential Tempered by Market Demands for Parking

Redevelopment Area (SF)	367,662	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	27%	*0*			
Redevelopment Area (SF) with Setback Reduction	**268,802**	**SF**			
Maximum lot coverage	100%	*0*			
Allowable Development Footprint	**268,802**	**SF**			
Maximum Building Stories	2		**Limited by development reality**		
Ground Floor Utilization Factor (GFUF)	48.50%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	130,369	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**130,369**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	215,041				
# of Office Stories	0				
# of Residential Stories	1				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**215,041**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**143**	Assume 2.243 residents per unit			
			2.243	**322**	Total Residents
			47.40%	**152**	Total Renters
			52.60%	**169**	Total Owners
Parking Factors (Per typical zoning factors):					
Note: The following is a calculation of parking which would be provided on-site to meet current market expectations, despite zoning allowance for zero parking.					

Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			
Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	32,592	25%	65		
Restaurant/ Theater/ Assembly	32,592	25%	326	Assumes 50% net SF is assembly	
Office	65,184	50%	261	75%	**equals 196 office workers**
Total:	**130,369**	**Total:**	**652**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	652	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	100%				
On-site commercial parking spaces	652				
# of Residential Parking Spaces	143	Equal to number of housing units. Assumes 1 space per unit.			
Residential Parking Factor	100%				
On-site residential parking spaces	143				
Total On-site Parking:	**795**				
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	238,562	SF			
% of Lot Required by Parking:	**65%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Ground Floor Lot Coverage	**35%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**49%**	Based on Allowable Development Footprint			
Development Potential	**149%**	Based on Allowable Development Footprint			
Conclusion: Meeting real world parking requirements results in very little housing, unrealized zoning height allowance, and a loss of ~51% of ground floor commercial development potential versus scenario 1.					

Scenario #3 - Development Potential Per Current Zoning with PRT

Redevelopment Area (SF)	367,662	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	26.9%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**268,802**	**SF**			
Maximum lot coverage	100%	*75% max/ zoning but Setback Reduction satisfies requirement*			
Allowable Development Footprint	**268,802**	**SF**			
Maximum Building Stories	4		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	67.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	180,097	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**180,097**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	215,041				
# of Office Stories	0				
# of Residential Stories	3				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**645,124**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**430**	Assume 2.243 residents per unit			
			2.243	**965**	Total Residents
			47.40%	**457**	Total Renters
			52.60%	**507**	Total Owners
Parking Factors (Per typical zoning factors):					

Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	45,024	25%	90		
Restaurant/ Theater/ Assembly	45,024	25%	450	Assumes 50% net SF is assembly	
Office	90,049	50%	360	75%	**equals 270 office workers**
Total:	**180,097**	**Total:**	**900**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	900	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	50%				
On-site commercial parking spaces	450				
# of Owner-occupied Parking Spaces	226	Assumes all renter parking is off-site.			
Residential Parking Factor	75%				
On-site residential parking spaces	170				
Total On-site Parking:	**620**	**Offsite Need:**		**350**	
		Office Parking		**90**	**25% of office spaces**
		Owner Parking		**57**	**Balance of owner-occupied not on-site**
		Renter Parking		**204**	**100% of renter parking**
Parking Demand Ratio	**72.9%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	185,973	SF			
% of Lot Required by Parking:	**51%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Lot Covered by Building:	**49%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**67%**	Based on Allowable Development Footprint			
Development Potential	**367%**	Based on Allowable Development Footprint			

Conclusion: Residential development potential is only limited by off-site parking accommodation. Ground floor commercial development realized is 67% of zoning potential while providing market-required on-site parking, making development more economically feasible. Higher density of residential development also results in a lower overall amount of parking required, because of the creation of a district sufficiently dense to support walk and transit mobility modes (approx..40ppl/ac). Off-site parking increases GF commercial space and allows street space to be more pedestrian friendly, even though there is no increase in housing density over scenario 1

Scenario #4 - Development Potential of Expanded Zoning Envelope

Redevelopment Area (SF)	367,662	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	26.9%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**268,802**	**SF**			
Maximum lot coverage	100%	*75% max/ zoning but Setback Reduction satisfies requirement*			
Allowable Development Footprint	**268,802**	**SF**			
Maximum Building Stories	7				
Ground Floor Utilization Factor (GFUF)	71.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	190,849	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**190,849**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	215,041				
# of Office Stories	0				
# of Residential Stories	6				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**1,290,249**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**860**	Assume 2.243 residents per unit			
			2.243	**1929**	Total Residents
			47.40%	**915**	Total Renters
			52.60%	**1015**	Total Owners
Parking Factors (Per typical zoning factors):					

M - 32

Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	47,712	25%	95		
Restaurant/ Theater/ Assembly	47,712	25%	477	Assumes 50% net SF is assembly	
Office	95,425	50%	382	75%	**equals 286 office workers**
Total:	**190,849**	**Total:**	**954**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	954	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Reduction Factor	50%				
On-site commercial parking spaces	477				
# of Owner-occupied Parking Spaces	452	Assumes all renter parking is off-site.			
Residential Parking Factor	25%				
On-site residential parking spaces	113				
Total On-site Parking:	**590**	**Offsite Need:**		**704**	
		Office Parking		**95**	**25% of office spaces**
		Owner Parking		**339**	**Balance of owner-occupied not on-site**
		Renter Parking		**269**	**Two thirds of renter parking**
Parking Demand Ratio	**71.3%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	177,070	SF			
% of Lot Required by Parking:	**48%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not			
% of Lot Covered by Building:	**52%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**71%**	Based on Allowable Development Footprint			
Development Potential	**671%**	Based on Allowable Development Footprint			

Conclusion: Residential development potential is only limited by off-site parking accommodation and reasonable building height. Commercial development realized is 71% of zoning potential while providing market-required parking. Increase in housing density further reduces overall demand for both on and off site parking because of the increasing walk/transit friendliness of the district.

Development Analysis CBD:

Zoning Requirements:	
Off-Street Parking Requirement	None
Off-Street Loading Requirement	Same as B-2a
Minimum Lot Size	
Area (sq ft)	None
Width at Street Line (ft)	10
Max Building Height:	
Number of Stories	None
Height in Feet	average 80
Maximum Lot Coverage (%) by Buildings	100% except as required for rear yard, or side yard.
Yard Dimensions	
Front	None
Side	None
Side	None
Rear	10' min.
Minimum Building Height	25'
PRT Impact Area	277,392 ~2-3 minute walk (~750') from PRT within non-residential zones
	Includes subtracted buildings
Zoning Setback Reduction Analysis	
Hypothetical assembled redevelopment lot	12500
Lot size after setbacks are applied	11500
Setback Reduction %:	**8.0%**
FIELD KEY	
Calculated Value	
Value from Base Data	
Adjustable Input Value	

Scenario #1 - Theoretical Development Potential Per Current Zoning

Redevelopment Area (SF)	277,392	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	8.0%	*Approximated value via separate analysis*			
Redevelopment Area (SF) with Setback Reduction	**255,201**	**SF**			
Maximum lot coverage	100%	*Rear yard exception covered by Setback Reduction*			
Allowable Development Footprint	**255,201**	**SF**			
Maximum Building Stories	8		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	100.00%		Assumes development feasibilty relies on off-site parking		
Actual Commercial Footprint (per GFUF)	255,201	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**255,201**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	204,161				
# of Office Stories	0				
# of Residential Stories	7				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**1,429,126**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**953**	Assume 2.243 residents per unit			
			2.243	**2137**	Total Residents
			47.40%	**1013**	Total Renters
			52.60%	**1124**	Total Owners
Parking Factors (Per typical zoning factors):					
Note: The following is a calculation of parking which would be required to meet typical market expectations despite zoning allowance for zero parking. *It is assumed that viable commercial development will rely on the provision of off-street parking or parking garages independent of any zoning*					
Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			
Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			

M - 35

Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	63,800	25%	128		
Restaurant/ Theater/ Assembly	63,800	25%	638	Assumes 50% net SF is assembly	
Office	127,601	50%	510	75%	**equals 383 office workers**
Total:	**255,201**	**Total:**	**1276**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	1276	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	100%				
On-site commercial parking spaces	1276				
# of Residential Parking Spaces	953	Equal to number of housing units. Assumes 1 space per unit.			
Residential Parking Factor	100%				
On-site residential parking spaces	953				
Total On-site Parking:	**2229**				
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	**0**	SF	**This value set to zoning allowance for no parking**		
% of Lot Required by Parking:	**0%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Ground Floor Lot Coverage	**92%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**92%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**100%**	Based on Allowable Development Footprint			
Development Potential	**800%**	Based on Allowable Development Footprint			
Conclusion: This scenario is realistic under current market conditions only if garage parking is provided. Provision of garage parking (with ground floor retail) would result in the loss of 357 units. See scenario 2 for development potential if on-site parking is provided. See scenario 3 for development potential if off-site parking with transit circulator is provided.					
Gross above grade space (SF)	1,786,407				
Commercial parking space requirement (SF)	(382,802)				
Space left on above grade stories for residential parking and dwelling units (SF)	1,403,606				
Residential parking space requirement (SF)	193,601				
# of residential parking spaces	645				
# of residential units	645	Assume 2.243 residents per unit			
			2.243	**1447**	Total Residents
			47.40%	**686**	Total Renters
			52.60%	**761**	Total Owners
Total public garage spaces	1,921				

Scenario #2 - Actual Development Potential Tempered by Market Demands for Parking

Redevelopment Area (SF)	277,392	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	8%	*0*			
Redevelopment Area (SF) with Setback Reduction	**255,201**	**SF**			
Maximum lot coverage	100%	*0*			
Allowable Development Footprint	**255,201**	**SF**			
Maximum Building Stories	2		**Limited by development reality**		
Ground Floor Utilization Factor (GFUF)	37.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	94,424	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**94,424**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	204,161				
# of Office Stories	0				
# of Residential Stories	1				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**204,161**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**136**	Assume 2.243 residents per unit			
			2.243	**305**	Total Residents
			47.40%	**145**	Total Renters
			52.60%	**161**	Total Owners
Parking Factors (Per typical zoning factors):					
Note: The following is a calculation of parking which would be provided on-site to meet current market expectations, despite zoning allowance for zero parking.					

Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			
Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	23,606	25%	47		
Restaurant/ Theater/ Assembly	23,606	25%	236	Assumes 50% net SF is assembly	
Office	47,212	50%	189	75%	**equals 142 office workers**
Total:	**94,424**	**Total:**	**472**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	472	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	100%				
On-site commercial parking spaces	472				
# of Residential Parking Spaces	136	Equal to number of housing units. Assumes 1 space per unit.			
Residential Parking Factor	100%				
On-site residential parking spaces	136				
Total On-site Parking:	**608**				
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	182,469	SF			
% of Lot Required by Parking:	**66%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Ground Floor Lot Coverage	**34%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**37%**	Based on Allowable Development Footprint			
Development Potential	**137%**	Based on Allowable Development Footprint			
Conclusion: Meeting real world parking requirements results in very little housing, unrealized zoning height allowance, and a loss of ~63% of ground floor commercial development potential versus scenario 1.					

Scenario #3 - Development Potential Per Current Zoning with PRT

Redevelopment Area (SF)	277,392	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	8.0%	*Approximated value via separate analysis*			
Redevelopment Area (SF) with Setback Reduction	**255,201**	**SF**			
Maximum lot coverage	100%	*Rear yard exception covered by Setback Reduction*			
Allowable Development Footprint	**255,201**	**SF**			
Maximum Building Stories	8		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	37.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	94,424	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**94,424**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	204,161				
# of Office Stories	0				
# of Residential Stories	7				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**1,429,126**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**953**	Assume 2.243 residents per unit			
			2.243	**2137**	Total Residents
			47.40%	**1013**	Total Renters
			52.60%	**1124**	Total Owners
Parking Factors (Per typical zoning factors):					

M - 39

Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	23,606	25%	47		
Restaurant/ Theater/ Assembly	23,606	25%	236	Assumes 50% net SF is assembly	
Office	47,212	50%	189	75%	**equals 142 office workers**
Total:	**94,424**	**Total:**	**472**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	472	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	50%				
On-site commercial parking spaces	236				
# of Owner-occupied Parking Spaces	501	Assumes all renter parking is off-site.			
Residential Parking Factor	75%				
On-site residential parking spaces	376				
Total On-site Parking:	**612**	**Offsite Need:**		**624**	
		Office Parking		**47**	**25% of office spaces**
		Owner Parking		**125**	**Balance of owner-occupied not on-site**
		Renter Parking		**452**	**100% of renter parking**
Parking Demand Ratio	**86.7%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	183,576	SF			
% of Lot Required by Parking:	**66%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Lot Covered by Building:	**34%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**37%**	Based on Allowable Development Footprint			
Development Potential	**737%**	Based on Allowable Development Footprint			
Conclusion: Residential development potential is only limited by off-site parking accommodation. Ground floor commercial development realized is 44% of zoning potential while providing market-required on-site parking, making development more economically feasible. Higher density of residential development also results in a lower overall amount of parking required, because of the creation of a district sufficiently dense to support walk and transit mobility modes (approx..40ppl/ac). Off-site parking increases GF commercial space and allows street space to be more pedestrian friendly, even though there is no increase in housing density over scenario 1					

Scenario #4 - Development Potential of Expanded Zoning Envelope

Redevelopment Area (SF)	277,392	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	8.0%	*Approximated value via separate analysis*			
Redevelopment Area (SF) with Setback Reduction	**255,201**	**SF**			
Maximum lot coverage	100%	*Rear yard exception covered by Setback Reduction*			
Allowable Development Footprint	**255,201**	**SF**			
Maximum Building Stories	11				
Ground Floor Utilization Factor (GFUF)	50.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	127,601	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**127,601**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	204,161				
# of Office Stories	0				
# of Residential Stories	10				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**2,041,608**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**1361**	Assume 2.243 residents per unit			
			2.243	**3053**	Total Residents
			47.40%	**1447**	Total Renters
			52.60%	**1606**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100

M - 41

Ground Floor Retail-Restaurant-Office Mix:	Area (SF)	Mix	Spaces		
Retail	31,900	25%	64		
Restaurant/ Theater/ Assembly	31,900	25%	319	Assumes 50% net SF is assembly	
Office	63,800	50%	255	75%	**equals 191 office workers**
Total:	**127,601**	**Total:**	**638**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	638	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Reduction Factor	50%				
On-site commercial parking spaces	319				
# of Owner-occupied Parking Spaces	716	Assumes all renter parking is off-site.			
Residential Parking Factor	25%				
On-site residential parking spaces	179				
Total On-site Parking:	**498**	**Offsite Need:**		**1027**	
		Office Parking		**64**	**25% of office spaces**
		Owner Parking		**537**	**Balance of owner-occupied not on-site**
		Renter Parking		**426**	**Two thirds of renter parking**
Parking Demand Ratio	**76.3%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	149,395	SF			
% of Lot Required by Parking:	**54%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not			
% of Lot Covered by Building:	**46%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**50%**	Based on Allowable Development Footprint			
Development Potential	**1050%**	Based on Allowable Development Footprint			

Conclusion: Residential development potential is only limited by off-site parking accommodation and reasonable building height. Commercial development realized is 50% of zoning potential while providing market-required parking. Increase in housing density further reduces overall demand for both on and off site parking because of the increasing walk/transit friendliness of the district.

Development Analysis SW-2:					
Zoning Requirements:					
Off-Street Parking Requirement	Provide per zoning				
Off-Street Loading Requirement	Same as B-2a				
Minimum Lot Size					
Area (sq ft)	3000				
Width at Street Line (ft)	40				
Max Building Height:					
Number of Stories	5				
Height in Feet	60				
Maximum Lot Coverage (%) by Buildings	60%				
Yard Dimensions					
Front	Min: 15'; Max: 34' from curb				
Side	None				
Side	None				
Rear	15% or 20'				
Minimum Building Height	None				
PRT Impact Area	1,229,047	~2-3 minute walk (~750') from PRT within non-residential zones			
		Includes subtracted buildings			
Zoning Setback Reduction Analysis					
Hypothetical assembled redevelopment lot	120000				
Lot size after setbacks are applied	108000				
Setback Reduction %:	**10.0%**				
FIELD KEY					
Calculated Value					
Value from Base Data					
Adjustable Input Value					

Scenario #1 - Theoretical Development Potential Per Current Zoning

Redevelopment Area (SF)	1,229,047	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0.0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**1,229,047**	**SF**			
Maximum lot coverage	60%	*Per zoning*			
Allowable Development Footprint	**737,428**	**SF**			
Maximum Building Stories	5		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	41.00%		*Adjusted to provide off-street parking per zoning*		
Actual Commercial Footprint (per GFUF)	302,346	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**302,346**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	589,943				
# of Office Stories	0				
# of Residential Stories	4				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**2,359,770**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**1573**	Assume 2.243 residents per unit			
			2.243	**3529**	Total Residents
			47.40%	**1673**	Total Renters
			52.60%	**1856**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			
Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			

Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	75,586	25%	151		
Restaurant/ Theater/ Assembly	75,586	25%	756	Assumes 50% net SF is assembly	
Office	151,173	50%	605	75%	**equals 454 office workers**
Total:	**302,346**	**Total:**	**1512**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	1512	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	100%				
On-site commercial parking spaces	1512				
# of Residential Parking Spaces	1573	Equal to number of housing units. Assumes 1 space per unit.			
Residential Parking Factor	100%				
On-site residential parking spaces	1573				
Total On-site Parking:	**3085**				
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	**925,472**	SF			
% of Lot Required by Parking:	**75%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Ground Floor Lot Coverage	**25%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**41%**	Based on Allowable Development Footprint			
Development Potential	**441%**	Based on Allowable Development Footprint			
Scenario #2 - Actual Development Potential Tempered by Market Demands for Parking - same as scen					

Scenario #3 - Development Potential Per Current Zoning with PRT

Redevelopment Area (SF)	1,229,047	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0.0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**1,229,047**	**SF**			
Maximum lot coverage	60%	*Per zoning*			
Allowable Development Footprint	**737,428**	**SF**			
Maximum Building Stories	5		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	81.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	597,317	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**597,317**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	589,943				
# of Office Stories	0				
# of Residential Stories	4				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**2,359,770**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**1573**	Assume 2.243 residents per unit			
			2.243	**3529**	Total Residents
			47.40%	**1673**	Total Renters
			52.60%	**1856**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100

Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	149,329	25%	299		
Restaurant/ Theater/ Assembly	149,329	25%	1493	Assumes 50% net SF is assembly	
Office	298,658	50%	1195	75%	**equals 896 office workers**
Total:	**597,317**	**Total:**	**2987**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	2987	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	50%				
On-site commercial parking spaces	1493				
# of Owner-occupied Parking Spaces	827	Assumes all renter parking is off-site.			
Residential Parking Factor	75%				
On-site residential parking spaces	621				
Total On-site Parking:	**2114**	**Offsite Need:**		**1251**	
		Office Parking		**299**	**25% of office spaces**
		Owner Parking		**207**	**Balance of owner-occupied not on-site**
		Renter Parking		**746**	**100% of renter parking**
Parking Demand Ratio	**73.8%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	634,174	SF			
% of Lot Required by Parking:	**52%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Lot Covered by Building:	**49%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**81%**	Based on Allowable Development Footprint			
Development Potential	**481%**	Based on Allowable Development Footprint			
Conclusion: Residential development potential is only limited by off-site parking accommodation. Ground floor commercial development realized is 81% of zoning potential while providing market-required on-site parking, making development more economically feasible. Higher density of residential development also results in a lower overall amount of parking required, because of the creation of a district sufficiently dense to support walk and transit mobility modes (approx..40ppl/ac). Off-site parking increases GF commercial space and allows street space to be more pedestrian friendly, even though there is no increase in housing density over scenario 1					

Scenario #4 - Development Potential of Expanded Zoning Envelope

Redevelopment Area (SF)	1,229,047	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0.0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**1,229,047**	**SF**			
Maximum lot coverage	60%	*Per zoning*			
Allowable Development Footprint	**737,428**	**SF**			
Maximum Building Stories	9				
Ground Floor Utilization Factor (GFUF)	85.50%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	630,501	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**630,501**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	589,943				
# of Office Stories	0				
# of Residential Stories	8				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**4,719,540**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**3146**	Assume 2.243 residents per unit			
			2.243	**7057**	Total Residents
			47.40%	**3345**	Total Renters
			52.60%	**3712**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100

Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	157,625	25%	315		
Restaurant/ Theater/ Assembly	157,625	25%	1576	Assumes 50% net SF is assembly	
Office	315,251	50%	1261	75%	**equals 946 office workers**
Total:	**630,501**	**Total:**	**3153**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	3153	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Reduction Factor	50%				
On-site commercial parking spaces	1576				
# of Owner-occupied Parking Spaces	1655	Assumes all renter parking is off-site.			
Residential Parking Factor	25%				
On-site residential parking spaces	414				
Total On-site Parking:	**1990**		**Offsite Need:**	**2541**	
			Office Parking	**315**	**25% of office spaces**
			Owner Parking	**1241**	**Balance of owner-occupied not on-site**
			Renter Parking	**984**	**Two thirds of renter parking**
Parking Demand Ratio	**71.9%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	597,000	SF			
% of Lot Required by Parking:	**49%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not			
% of Lot Covered by Building:	**51%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**86%**	Based on Allowable Development Footprint			
Development Potential	**886%**	Based on Allowable Development Footprint			

Conclusion: Residential development potential is only limited by off-site parking accommodation and reasonable building height. Commercial development realized is 86% of zoning potential while providing market-required parking. Increase in housing density further reduces overall demand for both on and off site parking because of the increasing walk/transit friendliness of the district.

Development Analysis B-2a:

Zoning Requirements:		
Off-Street Parking Requirement	Provide per zoning	
Off-Street Loading Requirement	Provide per zoning	
Minimum Lot Size		
Area (sq ft)	3000	
Width at Street Line (ft)	40	
Max Building Height:		
Number of Stories	6	
Height in Feet	70	
Maximum Lot Coverage (%) by Buildings	50%	
Yard Dimensions		
Front	None	
Side	10	
Side	5	
Rear	15% or 20'	
Minimum Building Height	None	
PRT Impact Area	210,694	~2-3 minute walk (~750') from PRT within non-residential zones
		Includes subtracted buildings
Zoning Setback Reduction Analysis		
Hypothetical assembled redevelopment lot	14000	
Lot size after setbacks are applied	10200	
Setback Reduction %:	**27.1%**	
FIELD KEY		
Calculated Value		
Value from Base Data		
Adjustable Input Value		

Scenario #1 - Theoretical Development Potential Per Current Zoning

Redevelopment Area (SF)	210,694	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0.0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**210,694**	**SF**			
Maximum lot coverage	50%	*Per zoning*			
Allowable Development Footprint	**105,347**	**SF**			
Maximum Building Stories	6		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	48.00%		*Adjusted to provide off-street parking per zoning*		
Actual Commercial Footprint (per GFUF)	50,566	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**50,566**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	84,277				
# of Office Stories	0				
# of Residential Stories	5				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**421,387**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**281**	Assume 2.243 residents per unit			
			2.243	**630**	Total Residents
			47.40%	**299**	Total Renters
			52.60%	**331**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			
Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			

Ground Floor Retail-Restaurant-Office Mix:	Area (SF)	Mix	Spaces		
Retail	12,642	25%	25		
Restaurant/ Theater/ Assembly	12,642	25%	126	Assumes 50% net SF is assembly	
Office	25,283	50%	101	75%	**equals 76 office workers**
Total:	**50,566**	**Total:**	**253**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	253	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	100%				
On-site commercial parking spaces	253				
# of Residential Parking Spaces	281	Equal to number of housing units. Assumes 1 space per unit.			
Residential Parking Factor	100%				
On-site residential parking spaces	281				
Total On-site Parking:	**534**				
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	**160,200**	SF			
% of Lot Required by Parking:	**76%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Ground Floor Lot Coverage	**24%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**48%**	Based on Allowable Development Footprint			
Development Potential	**548%**	Based on Allowable Development Footprint			
Scenario #2 - Actual Development Potential Tempered by Market Demands for Parking - same as scen					

Scenario #3 - Development Potential Per Current Zoning with PRT

Redevelopment Area (SF)	210,694	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0.0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**210,694**	**SF**			
Maximum lot coverage	50%	*Per zoning*			
Allowable Development Footprint	**105,347**	**SF**			
Maximum Building Stories	6		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	96.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	101,133	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**101,133**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	84,277				
# of Office Stories	0				
# of Residential Stories	5				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**421,387**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**281**	Assume 2.243 residents per unit			
			2.243	**630**	Total Residents
			47.40%	**299**	Total Renters
			52.60%	**331**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100

Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	25,283	25%	51		
Restaurant/ Theater/ Assembly	25,283	25%	253	Assumes 50% net SF is assembly	
Office	50,566	50%	202	75%	**equals 152 office workers**
Total:	**101,133**	**Total:**	**506**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	506	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	50%				
On-site commercial parking spaces	253				
# of Owner-occupied Parking Spaces	148	Assumes all renter parking is off-site.			
Residential Parking Factor	75%				
On-site residential parking spaces	111				
Total On-site Parking:	**364**	**Offsite Need:**		**221**	
		Office Parking		**51**	**25% of office spaces**
		Owner Parking		**37**	**Balance of owner-occupied not on-site**
		Renter Parking		**133**	**100% of renter parking**
Parking Demand Ratio	**74.3%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	109,097	SF			
% of Lot Required by Parking:	**52%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Lot Covered by Building:	**48%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**96%**	Based on Allowable Development Footprint			
Development Potential	**596%**	Based on Allowable Development Footprint			

Conclusion: Residential development potential is only limited by off-site parking accommodation. Ground floor commercial development realized is 96% of zoning potential while providing market-required on-site parking, making development more economically feasible. Higher density of residential development also results in a lower overall amount of parking required, because of the creation of a district sufficiently dense to support walk and transit mobility modes (approx..40ppl/ac). Off-site parking increases GF commercial space and allows street space to be more pedestrian friendly, even though there is no increase in housing density over scenario 1

Scenario #4 - Development Potential of Expanded Zoning Envelope

Redevelopment Area (SF)	210,694	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0.0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**210,694**	**SF**			
Maximum lot coverage	50%	*Per zoning*			
Allowable Development Footprint	**105,347**	**SF**			
Maximum Building Stories	11				
Ground Floor Utilization Factor (GFUF)	100.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	105,347	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**105,347**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	84,277				
# of Office Stories	0				
# of Residential Stories	10				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**842,774**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**562**	Assume 2.243 residents per unit			
			2.243	**1260**	Total Residents
			47.40%	**597**	Total Renters
			52.60%	**663**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100

Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	26,337	25%	53		
Restaurant/ Theater/ Assembly	26,337	25%	263	Assumes 50% net SF is assembly	
Office	52,673	50%	211	75%	**equals 158 office workers**
Total:	**105,347**	**Total:**	**527**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	527	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Reduction Factor	50%				
On-site commercial parking spaces	263				
# of Owner-occupied Parking Spaces	296	Assumes all renter parking is off-site.			
Residential Parking Factor	25%				
On-site residential parking spaces	74				
Total On-site Parking:	**337**		**Offsite Need:**	**450**	
			Office Parking	**53**	**25% of office spaces**
			Owner Parking	**222**	**Balance of owner-occupied not on-site**
			Renter Parking	**176**	**Two thirds of renter parking**
Parking Demand Ratio	**72.3%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	101,175	SF			
% of Lot Required by Parking:	**48%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not			
% of Lot Covered by Building:	**50%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**98%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**100%**	Based on Allowable Development Footprint			
Development Potential	**1100%**	Based on Allowable Development Footprint			

Conclusion: Residential development potential is only limited by off-site parking accommodation and reasonable building height. Commercial development realized is 100% of zoning potential while providing market-required parking. Increase in housing density further reduces overall demand for both on and off site parking because of the increasing walk/transit friendliness of the district.

Development Analysis B-4:

Zoning Requirements:		
Off-Street Parking Requirement	Provide per zoning	
Off-Street Loading Requirement	Provide per zoning	
Minimum Lot Size		
Area (sq ft)	3000	
Width at Street Line (ft)	40	
Max Building Height:		
Number of Stories	4	
Height in Feet	40	
Maximum Lot Coverage (%) by Buildings	50%	
Yard Dimensions		
Front	None	
Side	10	
Side	5	
Rear	15% or 20'	
Minimum Building Height	None	
PRT Impact Area	305,471	~2-3 minute walk (~750') from PRT within non-residential zones
		Includes subtracted buildings
Zoning Setback Reduction Analysis		
Hypothetical assembled redevelopment lot	21250	
Lot size after setbacks are applied	16275	
Setback Reduction %:	**23.4%**	
FIELD KEY		
Calculated Value		
Value from Base Data		
Adjustable Input Value		

Scenario #1 - Theoretical Development Potential Per Current Zoning

Redevelopment Area (SF)	305,471	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0.0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**305,471**	**SF**			
Maximum lot coverage	50%	*Per zoning*			
Allowable Development Footprint	**152,736**	**SF**			
Maximum Building Stories	4		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	61.00%		*Adjusted to provide off-street parking per zoning*		
Actual Commercial Footprint (per GFUF)	93,169	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**93,169**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	122,188				
# of Office Stories	0				
# of Residential Stories	3				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**366,565**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**244**	Assume 2.243 residents per unit			
			2.243	**548**	Total Residents
			47.40%	**260**	Total Renters
			52.60%	**288**	Total Owners
Parking Factors (Per typical zoning factors):					

Dwelling unit	1	per 3 bedroom			
Office	1 per 250	SF of gross building area			
Retail	1 per 500	SF of gross building area			
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	23,292	25%	47		
Restaurant/ Theater/ Assembly	23,292	25%	233	Assumes 50% net SF is assembly	
Office	46,584	50%	186	75%	**equals 140 office workers**
Total:	**93,169**	**Total:**	**466**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	466	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	100%				
On-site commercial parking spaces	466				
# of Residential Parking Spaces	244	Equal to number of housing units. Assumes 1 space per unit.			
Residential Parking Factor	100%				
On-site residential parking spaces	244				
Total On-site Parking:	**710**				
Parking Demand Ratio	**100%**	On-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	**213,066**	SF	**This value set to zoning allowance for no parking**		
% of Lot Required by Parking:	**70%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Ground Floor Lot Coverage	**31%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**100%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**61%**	Based on Allowable Development Footprint			
Development Potential	**361%**	Based on Allowable Development Footprint			

Scenario #2 - Actual Development Potential Tempered by Market Demands for Parking - same as scenario 1

Scenario #3 - Development Potential Per Current Zoning with PRT

Redevelopment Area (SF)	305,471	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0.0%	*Covered by lot coverage maximum below*			
Redevelopment Area (SF) with Setback Reduction	**305,471**	**SF**			
Maximum lot coverage	50%	*Per zoning*			
Allowable Development Footprint	**152,736**	**SF**			
Maximum Building Stories	4		**Per zoning requirements**		
Ground Floor Utilization Factor (GFUF)	100.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	152,736	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**152,736**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	122,188				
# of Office Stories	0				
# of Residential Stories	3				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**366,565**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**244**	Assume 2.243 residents per unit			
			2.243	**548**	Total Residents
			47.40%	**260**	Total Renters
			52.60%	**288**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		

Retail	38,184	25%	76		
Restaurant/ Theater/ Assembly	38,184	25%	382	Assumes 50% net SF is assembly	
Office	76,368	50%	305	75%	**equals 229 office workers**
Total:	**152,736**	**Total:**	**764**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			
Parking Requirement:					
# of Commercial Parking Spaces	764	Derived from Parking Mix Factor & Calculated Commercial SF			
Commercial Parking Factor	50%				
On-site commercial parking spaces	382				
# of Owner-occupied Parking Spaces	129	Assumes all renter parking is off-site.			
Residential Parking Factor	75%				
On-site residential parking spaces	96				
Total On-site Parking:	**478**	**Offsite Need:**		**224**	
		Office Parking		**76**	**25% of office spaces**
		Owner Parking		**32**	**Balance of owner-occupied not on-site**
		Renter Parking		**116**	**100% of renter parking**
Parking Demand Ratio	**69.7%**	On & off-site parking accommodation compared to total calculated parking			
Area per Parking Space	300				
Total Parking Footprint:	143,474	SF			
% of Lot Required by Parking:	**47%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)			
% of Lot Covered by Building:	**50%**	Actual Commercial Footprint/ Redevelopment Lot Size			
Total Lot Coverage by Buildings & Parking	**97%**	**Cannot exceed 100% (Adjust GFUF as required)**			
Ground Floor Utilization	**100%**	Based on Allowable Development Footprint			
Development Potential	**400%**	Based on Allowable Development Footprint			
Conclusion: Residential development potential is only limited by off-site parking accommodation. Ground floor commercial development realized is 100% of zoning potential while providing market-required on-site parking, making development more economically feasible. Higher density of residential development also results in a lower overall amount of parking required, because of the creation of a district sufficiently dense to support walk and transit mobility modes (approx..40ppl/ac). Off-site parking increases GF commercial space and allows street space to be more pedestrian friendly, even though there is no increase in housing density over scenario 1					
Scenario #4 - Development Potential of Expanded Zoning Envelope					
Redevelopment Area (SF)	305,471	Total lot area of zone (See PRT system map)			
Reduction due to zoning setbacks	0.0%	*Covered by lot coverage maximum below*			

Redevelopment Area (SF) with Setback Reduction	**305,471**	**SF**			
Maximum lot coverage	50%	*Per zoning*			
Allowable Development Footprint	**152,736**	**SF**			
Maximum Building Stories	7				
Ground Floor Utilization Factor (GFUF)	100.00%		Assumes development feasibilty relies on on-site parking		
Actual Commercial Footprint (per GFUF)	152,736	SF			
# of Commercial Stories	1				
Calculated Commercial Space (SF)	**152,736**	**SF**			
Above Grade Utilization Factor (AGUF)	80%		Assumes above grade development can cover non-building development footprint below. 20% reduction of development footprint accounts for building circulation.		
Actual Above Grade Footprint	122,188				
# of Office Stories	0				
# of Residential Stories	6				
Calculated Above Grade Office Space (SF)	**0**	**SF**	Actual above grade footprint x number of stories		
Calculated Residential Space (SF)	**733,130**	**SF**	Actual above grade footprint x number of stories		
Average Unit Size (SF)	1,500	SF	Derived from unit mix calculations.		
Number of Units	**489**	Assume 2.243 residents per unit			
			2.243	**1096**	Total Residents
			47.40%	**520**	Total Renters
			52.60%	**577**	Total Owners
Parking Factors (Per typical zoning factors):					
Dwelling unit	1	per 3 bedroom			**Variations used in Commercial Parking Factor:**
Office	1 per 250	SF of gross building area			1000
Retail	1 per 500	SF of gross building area			500
Restaurant/ Theater/ Assembly	1 per 50	net SF of assembly space			100
Ground Floor Retail-Restaurant-Office Mix:	**Area (SF)**	**Mix**	**Spaces**		
Retail	38,184	25%	76		
Restaurant/ Theater/ Assembly	38,184	25%	382	Assumes 50% net SF is assembly	
Office	76,368	50%	305	75%	**equals 229 office workers**
Total:	**152,736**	**Total:**	**764**		
Retail-Restaurant-Office Parking Mix	**1 per 200**	**SF of gross building area**			

Parking Requirement:				
# of Commercial Parking Spaces	764	Derived from Parking Mix Factor & Calculated Commercial SF		
Commercial Parking Reduction Factor	50%			
On-site commercial parking spaces	382			
# of Owner-occupied Parking Spaces	257	Assumes all renter parking is off-site.		
Residential Parking Factor	25%			
On-site residential parking spaces	64			
Total On-site Parking:	**446**	**Offsite Need:**	**422**	
		Office Parking	**76**	**25% of office spaces**
		Owner Parking	**193**	**Balance of owner-occupied not on-site**
		Renter Parking	**153**	**Two thirds of renter parking**
Parking Demand Ratio	**69.3%**	On & off-site parking accommodation compared to total calculated parking		
Area per Parking Space	300			
Total Parking Footprint:	133,833	SF		
% of Lot Required by Parking:	**44%**	Total Parking Footprint/ Redevelopment Area (Any required parking setbacks not considered)		
% of Lot Covered by Building:	**50%**	Actual Commercial Footprint/ Redevelopment Lot Size		
Total Lot Coverage by Buildings & Parking	**94%**	**Cannot exceed 100% (Adjust GFUF as required)**		
Ground Floor Utilization	**100%**	Based on Allowable Development Footprint		
Development Potential	**700%**	Based on Allowable Development Footprint		

Conclusion: Residential development potential is only limited by off-site parking accommodation and reasonable building height. Commercial development realized is 100% of zoning potential while providing market-required parking. Increase in housing density further reduces overall demand for both on and off site parking because of the increasing walk/transit friendliness of the district.

	City of Ithaca														Town of Ithaca		
	SW-2	SW-1	WEDZ-1a	B-1a	B-1b	CBD-60	CBD-140	CBD-85	CBD-100	CBD-120	B-4	B-2a	R-3b	U-1	I	NC	
Buildable Zoning Footprint (SF)	2,288,619	139,034	658,204	365,664	222,615	485,863	63,245	6,601			215,570	262,043	43,569	83,201	30,385,560	93,197	
Actual Development Footprint %	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	
Actual Development SF	1,373,171	83,420	394,923	219,398	133,569	291,518	37,947	3,961	0	0	129,342	157,226	26,142	49,921	18,231,336	55,918	
Other Development Footprint (yards, parking, green space)	915,448	55,614	263,282	146,266	89,046	194,345	25,298	2,641	0	0	86,228	104,817	17,428	33,281	12,154,224	37,279	
Current Zoning Stories	2	5	5	4	6	5	12	7	8	10	4	6	4	5	3	3	
Current Zoning Potential (SF)	2,746,343	417,102	1,974,613	877,594	801,416	1,457,588	455,366	27,725	0	0	517,367	943,355	104,567	249,604	54,694,008	167,754	
Commercial Floor Requirement	1.5	1.5	2	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
Calculated Commercial Space (SF)	2,059,757	125,131	592,384	219,398	200,354	437,276	56,921	5,941	0	0	194,013	235,839	39,212	74,881	27,347,004	83,877	
Calculated Residential Space (SF)	686,586	291,971	1,382,229	658,195	601,062	1,020,312	398,445	21,784	0	0	323,355	707,516	65,354	174,723	27,347,004	83,877	
Average Unit Size (SF)	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
Number of Units	458	195	921	439	401	680	266	15	0	0	216	472	44	116	18,231	56	
Proposed Stories	4	7	7	6	8	7	14	9	10	12	6	8	6	7	5	5	
Proposed Zoning Potential	5,492,686	583,942	2,764,458	1,316,391	1,068,554	2,040,623	531,260	35,647	0	0	776,051	1,257,807	156,850	349,446	91,156,680	279,590	
Proposed Commercial Space	2,059,757	125,131	592,384	219,398	200,354	437,276	56,921	5,941	0	0	194,013	235,839	39,212	74,881	27,347,004	83,877	
Proposed Residential Space	3,432,929	458,812	2,172,074	1,096,992	868,200	1,603,347	474,339	29,706	0	0	582,038	1,021,968	117,637	274,564	63,809,676	195,713	
Proposed Number of Units	2,289	306	1,448	731	579	1,069	316	20	0	0	388	681	78	183	42,540	130	
Off Street Parking Requirement																	
Off-Street Loading Requirement																	
Others?																	

Use Dist.	Off-Street Parking Requirement	Off-Street Loading Requirement	Sub. District	Minimum Lot Size: Area (sq ft)	Minimum Lot Size: Width at Street Line (ft)	Max Building Height: Number of Stories	Max Building Height: Height in Feet	Maximum Lot Coverage (%) by Buildings	Front	Side	Side	Rear	Minimum Building Height
R-1	1. Residence: a. 1 space for first 3 bedrooms/dwelling unit b. 2 spaces for 4 or 5 bedrooms/dwelling unit c. 1 space for ea. add'l bedroom in a unit 2. Other uses: See 325-20	1. Permitted non-residential uses: 1 space	R-1b	One-family detached: 6,000 Other uses: 7,500	One-family detached: 50 Other uses: 60	3	35	25	25	10	10	25% or 50'	None
R-2	1. Same as R-1 2. Home Occupation: 1 space 3. Neighborhood commercial facility: 1 space/500 gross sf of floor	1. Same as R-1 2. Home occupation: 1 space 3. Neighborhood Commercial facility: 1 space/50 gross sf of floor area	R-2a	One-family detached or 2-fam.: 5,000 Other uses: 6,000	One-family detached or semi-det or 2-fam.: 45 Other uses: 50	3	35	30	25	10	10	25% or 50'	None
			R-2b	One-family detached or 2-fam.: 3,000 Other uses: 4,000	One-family detached or semi-det or 2-fam.: 35 Other uses: 40	3	35	35	10	10	5	25% or 50'	None
R-3	1. Same as R-2 2. Rooming or boarding house: 1 space/3 pers. 3. Bed and Breakfast: 1 space/BR 4. Frat, sorority: 1 space/2 pers. 5. Dorm: 1 space/4 pers. 6. Hosp., nursing home: 1 space/5 beds	1. Same as R-2 2. Mult. dwlg. With 25 or more units: 1 space for up to 10,000 sf of floor space, plus 1 space for each add'l 15,000 sf 3. Nursing home, hosp.: 1 space	R-3a			4	440	65	10	10	5	20% or 50'	None
			R-3b			4	40	40	10	10	5	20% or 50'	None
B-1	1. Same as R-3 2. Funeral Home: 1 space/10seats 3. Business or prof. office: 1 space/250 sf of off. fl. 4. Other uses: see 325-20	1. Same as R-3 2. Office building: 1 space	B-1a	Residential	40	4	40	50	5	10	5	15% or 20'	None
	None		B-1b		30	6	50	90	5	5	5	10% or 15'	25
	1. Same as B-1 2. Retail Store: 1space/500 gross sf of floor area 3. Auditorium, theater: 1space/5 seats 4. Bar, restaurant: 1 space/50 sf net floor area in assembly space 5. Hotel: 1 space/guest rm. 6. Other uses: see 325-20	1. Same as B-1 2. Retail Store: 1 space for ea. use w/ 3,000-10,000 sf of fl space, plus 1 space for ea. add'l 15,000 sf of fl space in single occ. 3. Max required: 4 spaces for any single occ. 4. Other uses: See 325-21	B-2a		Motel: 100 All others: 40	6	70	50% (70% when adequate off street parking available)	None	10	5	15% or 20'	None

Use Dist.	Off-Street Parking Requirement	Off-Street Loading Requirement	Sub. District	Minimum Lot Size: Area (sq ft)	Minimum Lot Size: Width at Street Line (ft)	Max Building Height: Number of Stories	Max Building Height: Height in Feet	Maximum Lot Coverage (%) by Buildings	Front	Side	Side	Rear	Minimum Building Height
B-2	1. Residential uses: 1 space/3 persons housed 2. All other uses: see 325-20 except in a mixed use building, the parking requirement for any use on the ground floor only except office or res. Shall be waived when at least equal amount of gross area a the 2nd story or higher is devoted to res. use.	1. Same as B-2a. Retail Store: 1 space for ea. use w/ 3,000-10,000 sf of fl space, plus 1 space for ea. add'l 15,000 sf of fl space in single occ. 3. Max required: 4 spaces for any single occ. 4. Other uses: See 325-21	B-2b	Motel: 20,000 All others: 3,000	Motel: 100 All others: 25	6	60	100% Except as required for rear yard.	None	None	None	10' Min.	None
	None	None	B-2c	No minimum lot size	25	None	50	85% Except as required for rear yard, or side yard.	None	10	5	15% or 20'	25
	Same as B-2a except that there shall be no off-street parking requirement for residential use and further provided that there shall be no off-street parking required for any building in which 60% or more of the gross square footage is devoted to res. Use.	1. Same as B-2b 2. Retail Store: 1 space for ea. use w/ 3,000-10,000 sf of fl space, plus 1 space for ea. add'l 15,000 sf of fl space in single occ. 3. Max required: 4 spaces for any single occ. 4. Other uses: See 325-21	B-2d	3,000	40	None	40	75%	10	10	5	15% or 20'	25
B-4	Same as B-2a	Same as B-2a		3,000	40	4	40	50	None	10	5	15% or 20'	None
B-5	Same as B-4	Same as B-4		3,000	40	4	40	50	10	10	5	15% or 20'	None
CBD	None	Same as B-2a	CBD-60	No min. lot size	10	None	60	100% Except as required for rear yard.	None	None	None	10' Min.	25
			CBD-85	No min. lot size	10	None	85		None	None	None	10' Min.	25
			CBD-100	No min. lot size	10	None	100		None	None	None	10' Min.	25
			CBD-120	No min. lot size	10	None	120		None	None	None	10' Min.	25
			CBD-140	No min. lot size	10	12	140		None	None	None	10' Min.	25
I-1	1. Same as B-5 2. Wholesale, industrial and similar uses: 1 space/2 employees on maximum work shift, plus 1 space/500 sf to office or sales use.	1. Same as B-5 2. Industrial use: 1 space for ea. Use w/ 3,000-10,000 sf of floor space in single occupancy, plus 1 space for ea. add'l 15,000 sf.		5,000	50	4	40	50	20	12	6	15% or 20'	None
M-1	1. Same as B-5 2. All other uses: As required in 325-20 for uses similar in nature	Same as B-5		3,000	30 on street plus 30 on water, if water frontage	Res, hotel, boatel, and mixed uses:			See 325-26 for yards on creek, inlet or flood channel.				25
						5	50	50					
						All other uses:			All other cases:				
						3	35	60	5	5	5	15% or 20'	

Use Dist.	Off-Street Parking Requirement	Off-Street Loading Requirement	Sub. District	Minimum Lot Size: Area (sq ft)	Minimum Lot Size: Width at Street Line (ft)	Max Building Height: Number of Stories	Max Building Height: Height in Feet	Maximum Lot Coverage (%) by Buildings	Front	Side	Side	Rear	Minimum Building Height
P-1	1. Public Recreation: 1 space/10 persons viewing or participating 2. Institutional: As set forth above in 325-20 for similar specified uses	Institutional: As set forth above and in 325-21 for similar specific uses.		3,000	30	None	None	35	When yard on public street only				None
									25	10	10	10' Min.	
U-1	See section 325-20	None		No minimum lot size	None	None			None	None	None	None	None
WEDZ	None	None	WEDZ-1a	3,000	30	5 max 2 min	12' min. for 1st story measured from grade, 12' for each add'l story with an add'l 5' for cornice	100% for parcels 50' or less wide; 90% for parcels with 3 or more boundaries greater than 50' wide; Except as required for provision of 15' min/ 20' max curb setback and required rear yard and required buffer where commercial zone abuts residential zone and required accommodation of pedestrian ways and protection of view corridors designated in the West End Urban Design Plan 1999 (See Section 325-4)	None	None	None	10' Min.	2 stories or 24' (See Section 325-3B)
	1. Same as B-2a	1. Same as B-2a	WEDZ-1b	Motel: 20,000 All others: 3,000	Motel: 100 All others: 40 Width at Waterfront: 30'	2	12' min. for 1st story measured from grade, 12' for 2nd story with an add'l 5' for cornice; 1-story building must have added pitched roof or equivalent element		None	None	None	10' Min.	One story buildings must be a min. or 12' high w/ added pitched roof or equivalent
SW	Same as B-5	Same as B-5	SW-1	10,000	40	5	60	60%	Max 60' from curb	None	None	15% or 20'	Min. store size: 5,000 sq ft
	Same as SW-1	Same as SW-1	SW-2	3,000	40	5	60	60%	Min: 15' Max: 34' from curb	None	None	15% or 20'	None
	Same as SW-2	Same as SW-2	SW-3	3,000	40	2	40	60%	Min: 15' Max: 34' from curb	None	None	15% or 20'	Min. store size: 5,000 sq ft

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Appendix N: Ridership Forecast

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Estimated PRT Ridership from TOD Scenario 3

Total Housing Demand	1,444	Dwelling Units	(TOD area can accommodate 25.9% of total housing demand which is 2,464 units for relocating in-commuters, 2,740 units of overall demand, and 360 units of student housing, for a total of 5,564 units)
Relocating in-commuters	639	(All owned)	
Projected housing demand	711	(Owned / Rented)	Owned 52.60% Rented 47.40%
Student housing	93	(All rented)	
Total	1,444		
Condos (Owned)	1,014		
Apartments (Rented)	430		
Total	1,444		
Total Commercial Space	420,508	SF	(25% restaurant, bar, theatre, and performance venue, 25% retail, 50% office or professional service)

ITE Land Use: 820, Shopping Center, includes non-merchandising facilities such as movie theaters, restaurants, post offices, banks, health clubs and recreational facilities.
Thus, 25% of bar, restaurant, theatre and performance venue is combined into retail land use in the table below accounting for 50% of office and 50% of retail.

TOD Scenario 3 - ITE Trip Generation										
Land Use	ITE Code	Size		Daily	AM Peak Hour		PM Peak Hour		Saturday	Sunday
					Enter	Exit	Enter	Exit	Daily	Daily
Condo/Townhome	230	1014	Dwelling Units	5,888	76	370	353	174	5,747	4,905
Apartment	220	430	Dwelling Units	2,863	44	176	173	93	2,751	2,523
Retail	820	210.3	1000 SF Gross Leasable Area	11,008	146	93	513	534	14,757	7,501
Office	710	210.3	1000 SF Gross Floor Area	2,364	299	41	53	261	468	136
TOTAL				**22,123**	**565**	**680**	**1,092**	**1,062**	**23,723**	**15,065**

Percentage of residential trips by PRT 50%
Percentage of retail trips by PRT 50%
Percentage of office trips by PRT 50%

PRT Ridership - TOD Scenario 3						
Land Use	Weekday	Weekday AM Peak		Weekday PM Peak		Weekend
	Daily	Enter	Exit	Enter	Exit	Daily
Apartment	1,432	22	88	87	47	1,319
Condo/Townhome	2,944	38	185	177	87	2,663
Retail	5,504	73	47	257	267	5,565
Office	1,182	150	21	27	131	151
TOTAL	**11,062**	**283**	**340**	**546**	**531**	**9,697**
		AM Peak	623	PM Peak	1,077	

Refer to Appendix E for detail:
The on-site parking requirement for new offices is reduced assuming that 25% of employees would park off-site. In addition, 25% of office workers are assumed to live within the PRT service area and either walk or use PRT to get to work, resulting in 50% reduction in office parking demand.

As most of the new retail is expected to be of the kind serving the daily life needs of residents, (i.e. neighborhood groceries, cafes, news-stands, gyms, clothing stores, medical offices, etc) it is assumed that only 50% of retail and restaurant patrons would require parking, the remainder arrive on foot or use PRT.

Estimated PRT Ridership from TOD Scenario 4

Total Housing Demand	5,503 Dwelling Units	(TOD area can accommodate 99% of total housing demand which is 2,464 units for relocating in-commuters, 2,740 units of overall demand, and 360 units of student housing, for a total of 5,564 units)
Relocating in-commuters	2,437 (All owned)	
Projected housing demand	2,710 (Owned / Rented)	Owned 52.60% Rented 47.40%
Student housing	356 (All rented)	
Total	5,503	
Condos (Owned)	3,862	
Apartments (Rented)	1,641	
Total	5,503	
Total Commercial Space	907,572 SF	(25% restaurant, bar, theatre, and performance venue, 25% retail, 50% office or professional service)

ITE Land Use: 820, Shopping Center, includes non-merchandising facilities such as movie theaters, restaurants, post offices, banks, health clubs and recreational facilities.
Thus, 25% of bar, restaurant, theatre and performance venue is combined into retail land use in the table below accounting for 50% of office and 50% of retail.

TOD Scenario 4 - ITE Trip Generation

Land Use	ITE Code	Size		Daily	AM Peak Hour		PM Peak Hour		Saturday	Sunday
					Enter	Exit	Enter	Exit	Daily	Daily
Condo/Townhome	230	3862	Dwelling Units	22,438	289	1,410	1,346	663	21,898	18,692
Apartment	220	1641	Dwelling Units	10,913	167	670	661	356	10,486	9,616
Retail	820	453.8	1000 SF Gross Leasable Area	18,151	229	147	859	894	23,959	11,307
Office	710	453.8	1000 SF Gross Floor Area	4,275	554	75	100	487	990	263
TOTAL				**55,777**	**1,239**	**2,302**	**2,966**	**2,400**	**57,333**	**39,878**

Percentage of residential trips by PRT 50%
Percentage of retail trips by PRT 50%
Percentage of office trips by PRT 50%

PRT Ridership - TOD Scenario 4

Land Use	Weekday Daily	Weekday AM Peak		Weekday PM Peak		Weekend Daily
		Enter	Exit	Enter	Exit	
Apartment	5,457	84	335	331	178	5,026
Condo/Townhome	11,219	145	705	673	332	10,148
Retail	9,076	115	74	430	447	8,817
Office	2,138	277	38	50	244	313
TOTAL	**27,889**	**620**	**1,151**	**1,483**	**1,200**	**24,303**
		AM Peak	1,771	PM Peak	2,683	

Refer to Appendix E for detail:
The on-site parking requirement for new offices is reduced assuming that 25% of employees would park off-site. In addition, 25% of office workers are assumed to live within the PRT service area and either walk or use PRT to get to work, resulting in 50% reduction in office parking demand.

As most of the new retail is expected to be of the kind serving the daily life needs of residents, (i.e. neighborhood groceries, cafes, news-stands, gyms, clothing stores, medical offices, etc) it is assumed that only 50% of retail and restaurant patrons would require parking, the remainder arrive on foot or use PRT.

Appendix O: Cost Data

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February 4, 2010

Dear PRT Supplier,

Connect Ithaca LLC, in partnership with C&S Companies, has been contracted by the New York State Energy Research & Development Authority (NYSERDA) and the New York State Department of Transportation (NYSDOT) to conduct a preliminary feasibility study for the implementation of PRT/PodCar Systems in New York State.

Ithaca, NY has been selected as the case study site for the application of this technology. The city's population is **29,287** and the greater metropolitan area has a population of **100,135**. The total number of jobs within Tompkins County, where Ithaca is located, is **57,032**. The City is also home to Cornell University and Ithaca College.

From our early analysis, these demographics are consistent with areas that have a growing demand for transit and where PRT is stated to be the most efficient. Several recent local studies have also documented the need for improved transit service and the desire to have increased, yet sustainable, development density that would rely on alternative transportation modes.

For your information, our study will evaluate the feasibility of implementing a "Pilot" PRT system in Ithaca, NY and will include the following components:

- State of PRT development
- Application of PRT in Ithaca
- Project benefits
- Implementation
- Application in New York beyond Ithaca

A series of reports will document the progression of the study. **Technical Memorandum #1**, which has already been completed, summarized the origin, history, and status of PRT development in the U.S. and around the world. **Technical Memorandum #2**, which we are preparing now, documents the results of:

Research and data collection on transportation issues and travel behavior

Stakeholder outreach

Route prioritization

Technical feasibility

Right-of-way assessment

Constructability assessment

Assessment of transit-oriented development

Ridership forecasts

Capital costs, and

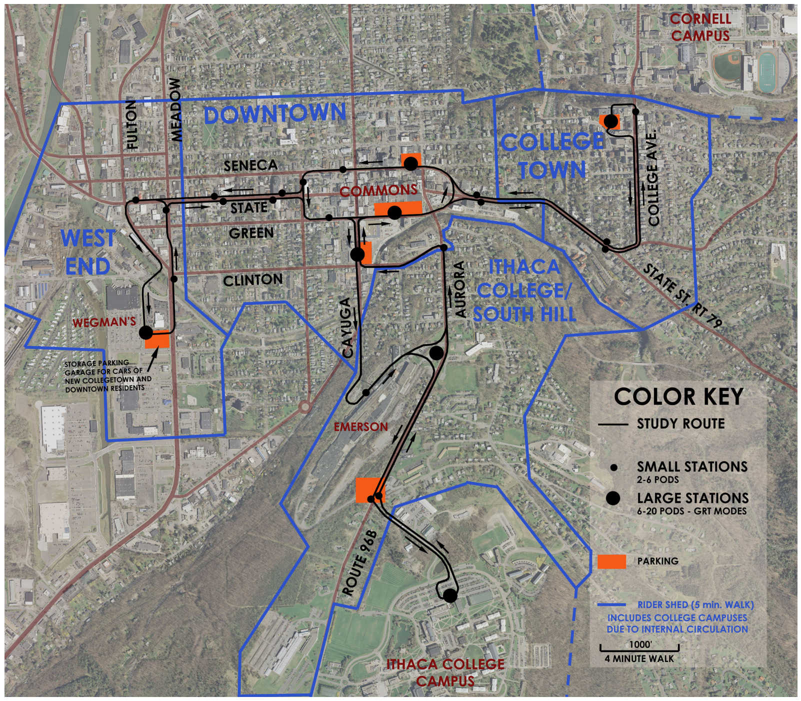
Operating and maintenance costs.

The intent of this outreach is to help us perform the *Capital; Operating & Maintenance cost analysis* for our study. The outlay information we are inquiring about is based on the physical scale of our Pilot Route (map attached) and our initial ridership estimates. We appreciate any time committed to supplying our investigators with this critical data. Please feel free to contact us with any questions or concerns you have about this request for information.

Sincerely,

Jacob Alan Roberts
President
Connect Ithaca LLC

Ithaca, NY - Pilot PRT Route Map



Our study team recognizes that a complete PRT system for Ithaca would include an extensive network connecting West Hill, South Hill and East Hill/Cayuga Heights; population areas located beyond the zone depicted in the map above. A larger PRT system would serve as a circulator between downtown and the major educational institutions, as a connector between park & ride facilities and major employment centers, and provide rapid access to additional transportation (Airport), retail (a large Mall), housing, and medical facilities on the city's perimeter.

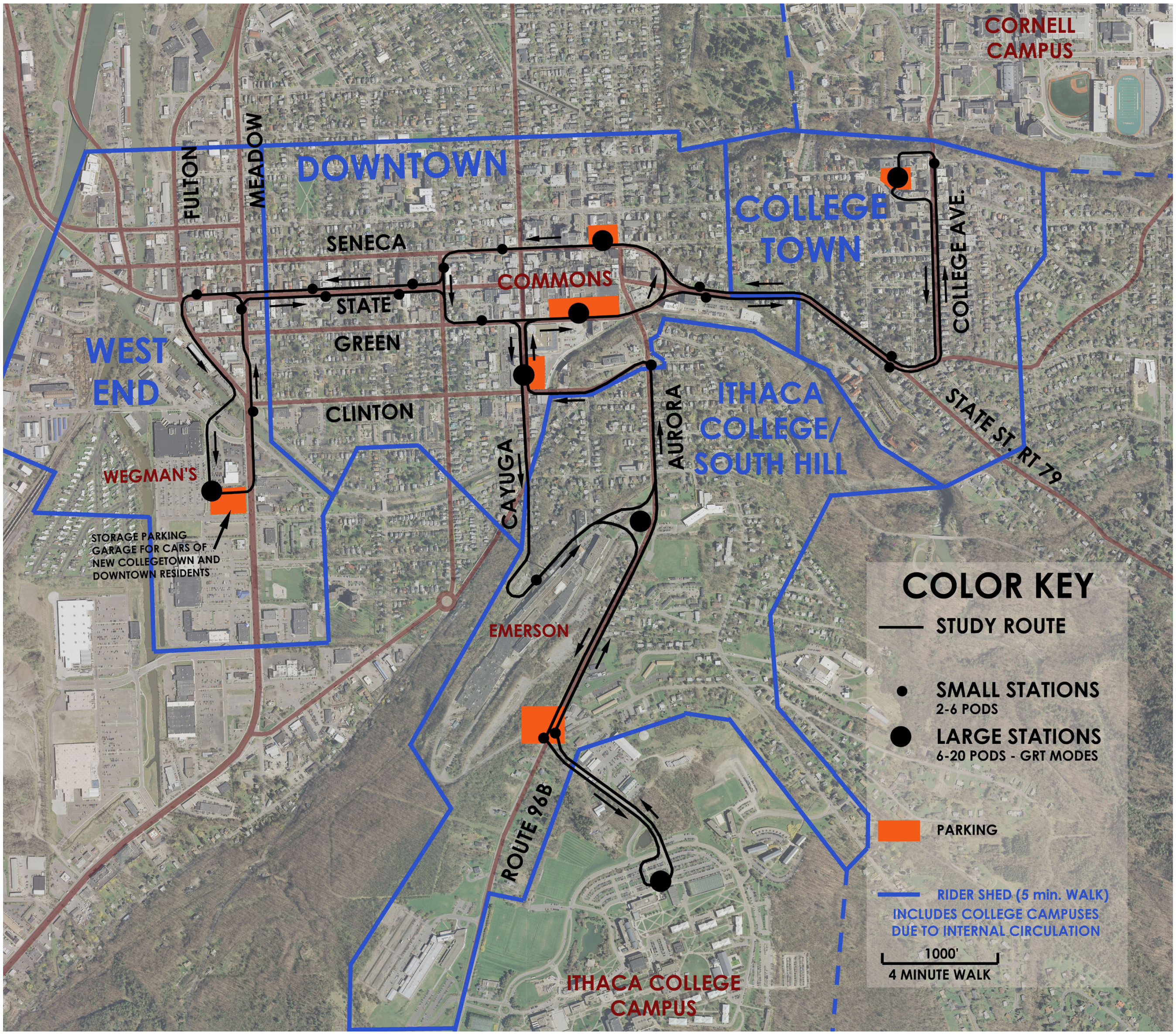
The extent of the PRT system being studied, however, is limited by the scope of funding and therefore focuses on a "Phase 1" section that will link Cornell University, Ithaca College, Downtown, and a grocery (Wegman's) / "Big Box" shopping district. These destinations were selected because they offer the highest density of workplaces in the county, have a broad mix of uses, and have a significant amount of existing housing within a five-minute walk of the proposed system. In addition to serving the aforementioned destinations, the following considerations were taken into account in the assessment of route prioritization:

- The area served by the route must have sufficient capacity to support new mixed-use, transit-oriented development (TOD).
- The route must provide access to storage parking location(s) to insure the near term market viability of new housing development, and ease existing parking problems in neighborhoods surrounding developed or developing areas like Collegetown.
- The route must extend to or include a location suitable for a storage, maintenance and operations facility.

Ultimately, the intent of the Ithaca PodCar system is to help reduce vehicle miles traveled (VMT) by creating a "PRT enabled mixed-use district" which contains all the essentials of daily life (work, education, services, recreation, food procurement, housing) within a maximum combined transit/walk trip of approximately 10 to 15 minutes.

As a result, PRT is being studied as an instrument to unite the city into an easily accessible whole; to connect parts of the city which are now remote from each other as measured by walking or biking. It is this perceived remoteness, exacerbated by the topography, which causes many students and residents to rely on automobiles for local trips.

Additionally, new transit-oriented housing constructed within the "PRT enabled mixed-use district" is anticipated to help fulfill the expressed demand for additional housing in Ithaca's core. Therefore, for the purposes of this *Capital; Operating & Maintenance cost analysis* we have provided you with anticipated ridership numbers that have been calculated to reflect a revised population index expected from maximum growth in Transit Oriented Development.



1. Physical Characteristics:

For your calculations, the linear length of **elevated track** for the Pilot Route is approx. **40,000 LF (12,195m)**** [29,900 LF (9115m) is single & 10,100 LF (3080m) is double]. ***This does not include length of track for station sidings and deceleration/acceleration sections.*

There are **7 large stations** (6 berths each plus deceleration/acceleration lengths) and **17 small stations** (2 berths each plus deceleration/acceleration lengths)

The system has **64 switches** (10 on mainline and the remainder for station sidings)

2. Estimated PRT Ridership

DHV (Demand Hourly Volume) - 5,830

Weekday Daily - 40,860

Weekend Daily - 28,690

Annual - 13,644,000

Accordingly, based on these figures and the attached map, we would therefore like to know the following information for inclusion in our *Capital; Operating & Maintenance cost analysis****: Estimates are welcome.

● number of vehicles required to meet anticipated ridership demand

● size and estimated cost of the maintenance / storage facility for that number of vehicles

● size of staff required to operate the PRT (mechanics, control monitors, administrators & other personnel)

● electricity required to operate the basic system (fyi: we are also tasked with identifying an appropriate alternative electricity source for the system)

● cost of the equipment

- Cost per mile for single track? *(Note: We will double cost for double track).*
- Cost per support pole?
- Cost per cross-beam between poles, if applicable?
- Cost per station ramp (switch plus acceleration or deceleration lane)?
- Cost per 2 berth station track?
- Cost per elevated 2 berth station platform (basic shelter with stairs & elevator)?
- Cost per elevated station platform per additional berth (basic shelter only)?
- Cost per 3-way intersection switch? 4-way intersection switch?
- Cost per merging switch?
- Cost per storage depot based on pod capacity?

● cost to engineer the system

● cost of training, technical support and commissioning

● control software licensing (cost per year)

● and any other equipment/services/factors provided by your company that we should include in a preliminary cost analysis

****note: our team will estimate other costs of implementation; such as:*

● public planning participation

● right of way acquisition / franchise fee

● legal cost

● ongoing operating costs (labor, insurance, benefits, etc)

● and local construction costs

● we will also make our own estimate of station and parking structure costs

PRELIMINARY ROW ACQUISITION COSTS

SWIS	Tax ID	Roll Section	Area (Acres)	Land Assessment	Per Acre Land Assessment	Easement Area (Acres)	Intrusiveness	Easement ROW Acquisition Cost	Estimated ROW Acquisition Cost
Tax Parcels that will have to provide easements for PRT Infrastructure									
500700	63.-5-1	Wholly Exempt	1.300						
500700	63.-5-8	Wholly Exempt	0.190						
500700	79.-2-1.2	Taxable	0.590	$200,000	$338,983	0.0803	80%	$21,790	$30,500
500700	79.-10-1	Taxable	1.410	$403,800	$286,383	0.2066	80%	$47,336	$66,300
Tax Parcels that will have to provide Large Stations									
500700	61.-4-5	Wholly Exempt	0.761						
500700	70.-4-5.2	Wholly Exempt	1.450						
500700	63.-5-7	Wholly Exempt	0.510						
500700	95.-1-1.2	Taxable	17.540	$3,881,000	$221,266	1.2544	80%	$222,038	$310,900
500700	81.-2-1	Wholly Exempt	1.630						
500700	106.-1-8	Wholly Exempt	31.000						
500700	41.-1-30.2	Wholly Exempt	585.890						
Tax Parcels that have to provide Small Stations									
500700	83.-3.8	Taxable	0.102	Full Acquisition					$50,000
500700	83.-2-11	Taxable	0.164	Full Acquisition					$190,000
500700	69.-2-19	Wholly Exempt	0.545						
500700	69.-6-3	Wholly Exempt	3.920						
500700	61.-6.9	Wholly Exempt	0.430						
500700	70.-6-20	Wholly Exempt	0.150						
500700	71.-3-1	Wholly Exempt	0.310						
500700	71.-2-5	Wholly Exempt	1.128						
500700	71.-5-5	Taxable	0.104	Full Acquisition					$20,000
500700	71.-1-3	Taxable	0.754	$600,000	$796,125	0.0275	80%	$17,545	$24,600
500700	71.-6-1	Taxable	0.536	$150,000	$279,978	0.0803	100%	$22,496	$31,500
500700	72.-4-23	Taxable	0.076						$30,000
500700	72.-2-1	Wholly Exempt	0.685						
500700	81.-5-1	Taxable	0.236	Full Acquisition					$320,000
500700	40.-3-3	Wholly Exempt	63.300						
								Total	$1,073,800
								Preliminary ROW Acquisition Cost Estimate	**$1,500,000**

Assumptions:

It is assumed that Tax Parcels that have Roll Section "Wholly Exempt" do not involve any ROW acquisition costs.

Estimated ROW Acquisition Cost includes the Easement ROW Acquisition Cost in addition to the following costs:

Negotiation/Project Mgmt Cost	15%	of Easement ROW Acquisition Cost
Engg Mapping & Survey Cost	15%	of Easement ROW Acquisition Cost
Legal Costs	10%	of Easement ROW Acquisition Cost

Thus the Estimated ROW Acquisition Cost is estimated as 140% of Easement ROW Acquisition Cost

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Appendix P: Comparison of Energy Use by Mode

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Energy Use of Current Modes of Transportation

Below is a series of charts that detail the energy use of current modes of transportation and endeavor to compare those figures with research conducted on the probable energy use of Personal Rapid Transit systems.

1. Lowson, M.V. "A new approach to sustainable transport systems," 2004

Transport Energy Use

Mode	BTU / passenger mile
PRT	839
Vanpool	1,362
Motorcycle	2,274
Commuter rail	2,714
Rail transit	3,268
Auto	3,581
Commercial Air	3,703
Personal truck	4,057
Bus transit	4,127
Amtrak	4,830

2. The Transportation Energy Data Book: Edition 25 - 2006, a publication prepared for the U.S. Department of Energy by the Oak Ridge National Laboratory. Energy consumption of car-bus-air compared:

Mode	BTUs/passenger mile	
Car, hybrid	1,326	(Honda Insight)
Van Pool	1,401	(National average)
Car, efficient	2,488	(2006 KIA Rio)
Commuter rail	2,751	
Amtrak	2,935	Amtrak
Light & heavy-rail transit	3,228	Light-rail & heavy-rail transit
Car, average	3,549	(National average)
Commercial air	3,587	(see note in link)
TriMet bus	3,792	(Data directly from TriMet)
Transit bus	4,160	(National average)

3. Ehlig-Economides & Longbottom "Dual Mode Vehicle & Infrastructure Analysis," TX DOT 2008.

Kilowatt-hours/passenger mile

PRT	0.60
Bus	0.95
Car	1.65
Light-rail	2.90

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Appendix Q: Solar PRT

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Solar PRT. Ron Swenson M.E.

How Can We Turn Sun Radiation into Automotion?, Ron Swenson, Sustainable Transportation Fund

Figure 3. Solar PRT. Ron Swenson M.E.

Solar PRT

	Input Variables -- can be modified for analysis
	Key assumptions
	Key results

	50	mi/hr, operating speed		
	73	ft in a sec (88 ft/sec = 60 mph)		
	2.0	sec podcar interval		
	147	ft between podcars		
	5,280	ft/mile		
	36	podcars/mi, separated by interval specified		
	6.5	kw @ operating speed including cabin load		
	20%	podcars empty ("deadheading")		
	281	kw needed in a mile stretch		
	5,280	ft/mi		
	53	watts needed / lineal ft at peak sun		
	10	hrs at peak operation equivalent		
	4.5	hrs of peak sun equivalent. Coast = 4, Desert = 6		
	2.2	solar factor		
	0.02	hrs to traverse one mile		
	0.13	kwh/vehicle-mile		
	118	watts / lineal ft per lane w/ solar factor		
	624,000	watts/mile		
$	6.00	/watt		
$	3,744,000	/mi		
	16	watts / sq ft, SunPower, most efficient on market		
	7.2	ft wide solar panel to meet requirement	$ 3,744,000	/mi
	3.6	ft wide solar panel to meet requirement	$ 1,872,000	/mi
	1.8	ft wide solar panel to meet requirement	$ 936,000	/mi
	0.9	ft wide solar panel to meet requirement	$ 468,000	/mi
	2.6	ft wide solar panel at existing manufactured size	$ 1,362,626	/mi
$	51,923	Cost to travel fleet mileage daily		
	18,951,923	Annual cost to travel fleet mileage		
$	93,600,000	Cost of solar to cover fleet mileage		
	4.9	years, Payback for solar system to save auto travel		

Figure 3. Continued..

Bicycle example

I built an electric bike that went 20 miles on 4 12 amp-hr 12v batteries

20	miles, range
20	mph, average
1	hr
0.58	kwh, battery storage capacity
0.58	kw average power during ride

podcar mpg equivalent

0.130	kwh/mi	124,000	btu/gallon per EIA
95	miles per gallon equivalent	10,000	btu/kwh
		12	kwh/gallon

Car example

570,000	cars per month on I-5 near Las Vegas
30	days per month
19,000	cars per day
2	people/podcar
38,000	passengers per day

Ridership Capacity

1.5	people/podcar
0.50	podcars per second
60	seconds / min
60	min / hr
2,700	passengers per hour at full capacity
10	hrs at peak operation equivalent
27,000	passengers per day
13,500	passengers per day
6,750	passengers per day
3,375	passengers per day
9,827	passengers per day

=30 kw at 40 km/hr

Electric vehicles for comparison

EV-1

100	mile range
50	mph (estimate)
2	hours
13	kwh/100 miles
6.50	kw

Appendix R: GHG Emissions Assumptions

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The transportation industry contributes approximately 29% of the greenhouse gases generated in the United States. Published information by the United States Environmental Protection Agency (USEPA) indicates that a gallon of gasoline produces approximately 8.8 kilograms or 19.4 pounds of carbon dioxide, while a gallon of diesel fuel produces 22.2 pounds of carbon dioxide. These approximations include an oxidation factor of 0.99, to account for the amount of carbon that remains unoxidized during combustion.

Besides carbon dioxide, the greenhouse gases, methane and nitrous oxide, are also emitted from vehicles while hydrofluorocarbons could potentially be released from faulty air conditioner units. These greenhouse gases have a greater global warming potential than carbon dioxide. On an average, the USEPA estimates that methane, nitrous oxide, and hydroflurorocarbons account for 5-6 percent of the greenhouse gas emissions from vehicles with carbon dioxide comprising the balance.

The Federal Highway Administration (FHWA) estimates that the average passenger car achieves a 22.1 miles per gallon fuel efficiency and light duty trucks achieve 17.6 miles per gallon, based on 2001 data. The overall weighted average fuel economy for passenger vehicles would be 20.3 miles per gallon.

Based on these factors, the following emission factors of total greenhouse gas emitted per average vehicle mile traveled were derived for various weight units. The factor of (100/95) accounts for the non carbon dioxide emissions associated with passenger vehicle emissions.

(1 mile/ 20.3 mpg) x 8.8 kg CO2e/gal x (100/95)/1000 =

0.0004563 metric ton CO2e per average vehicle mile traveled

(1 mile/ 20.3 mpg) x 19.4 lb CO2e/gal x (100/95) =

1.00596 pounds CO2e per average vehicle mile traveled

1.00596 pounds CO2e per average vehicle mile traveled / 2000 lb/ton =

0.0005029 short tons CO2e per average vehicle mile traveled

These emission factors account for carbon dioxide as well as the other greenhouse gases emitted by vehicles including methane, nitrous oxide, and hydrofluorocarbons. The data used in the calculation of greenhouse gas emission factors associated with vehicle miles traveled was based on 2001 information. It would be expected that the current average fuel economy would be greater due to the onset of hybrid, more fuel efficient vehicles, and changes in vehicle purchasing patterns.

It should be noted that this evaluation does not include the additional greenhouse gas emissions generated by the utility to accommodate the PRT electrical usage.

Diesel Usage

It has been reported that the standard diesel bus obtains approximately 3.5 miles per gallon. Using the carbon dioxide emission rate of 22.2 pounds per gallon of diesel combusted, the following emission factors of greenhouse emitted per average vehicle mile traveled was derived as follows:

(1 mile/ 3.5 mpg) x 22.2 lb CO_2e/gal =
6.3428 pounds CO_2e per average vehicle mile traveled

6.3428 pounds CO_2e per average vehicle mile traveled / 2000 lb/ton =
0.003171 short tons CO_2e per average vehicle mile traveled

22.2 lb CO_2e/gal x 0.45359 kg/lb = 10.07 kg CO_2e/gal

(1 mile/ 3.5 mpg) x 10.07 kg CO_2e/gal /1000 =
0.002877 metric ton CO_2e per average vehicle mile traveled

Documentation of the contribution of other greenhouse gases other than carbon dioxide for buses operating on diesel fuel was not determined at this time.

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[i] Morgantown People Mover – Updated Description. TRB 2005 Reviewing Committee: Circulation and Driverless Transit (AP040); http://en.wikipedia.org/wiki/Morgantown_Personal_Rapid_Transit

ii Engineering the ULTra System, Martin Lowson; www.alstd.co.uk