The Technology of Personal Rapid Transit

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Introduction

The technology of Personal Rapid Transit integrates the fundamental elements of the automotive industry, the aviation industry, and the rail/transit industry with the built environment. The fundamental sets of technologies present in each industry sector form their primary contributions to large scale urban PRT. In studying the history of PRT and the difficulty it has had in attaining successful large scale deployments, one can surmise that each industry group also offers their core competencies that underpin their technologies as the vital but missing components to the wide scale use of PRT as a mobility solution. The automotive industry offers its ability to provide personal wheeled mobility in an on-demand environment. The aviation industry offers its precision location, control and communications competencies for complex PRT networks in a highly regulated and controlled environment. Lastly, the rail and transit industry offers its integrated passenger safety competencies as its principal contribution all of which occur in a very structured environment. The integration of these competencies and their associated technologies in a common built environment is the challenge behind large scale PRT business case based deployments. Figure 1 shows the contributing industry sectors and their vital competencies as they relate to the technology of PRT and the built environment. An important and sometimes overlooked aspect of urban PRT planning has been a strong integration of the players representing each set of competencies to create viable concepts. Along with the transportation engineers and system designers, the urban planners and architects responsible for providing sustainable built environments of the future must collaborate to achieve a high level of integration of the mobility systems with their built and natural environments.

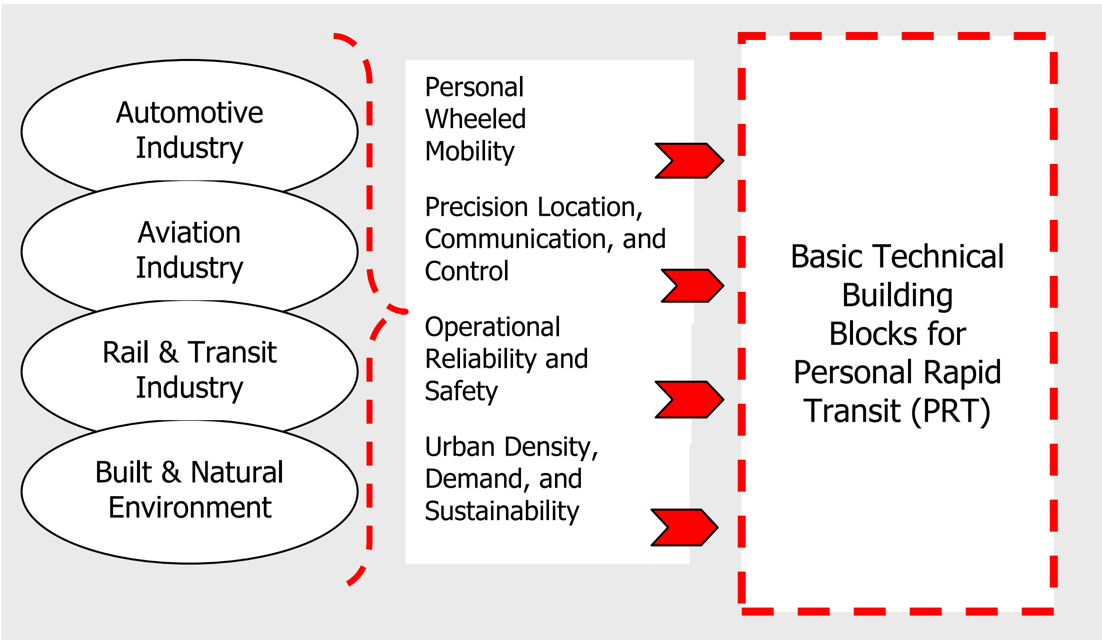


Figure 1. Vital Technical Competencies of the PRT

Each of these principle transportation modes (automotive, aviation, and rail/transit) also has inherent limitations surrounding their core competencies that they offer the technology of urban PRT. These limitations frequently are barriers to the technical evolution needed for providing advanced personal mobility for sustainable cities. The automotive industry requires as much as 30% of the urban land surface for its supporting network of roadways, and parking. Additionally, the automobiles widely use limited non-renewable fuels as energy sources. The aviation, and more specifically the information technology segment of the industry, requires extensive public governance and sophisticated control infrastructure as well as high passenger capacities to function efficiently. The rail and transit industry requires significant physical separation from other modes to ensure reliable and safe operations and also requires the presence of dense ridership patterns to operate efficiently.

When taken in the context of sustainable cities, the main barriers to sustainability for all three of the traditional modes include: significant infrastructure, significant financial capital and natural capital first costs, significant dependence on non-renewable energy, dense ridership based environments, extensive use of hazardous materials and potentially polluting fuels, oils, greases, and solvents, socio-economic stratification, and environmental impacts in the provision and maintenance of their supporting infrastructure systems.[1]

While perhaps not yet a complete solution to all of the issues that surround personal mobility for sustainable cities, the technology of a well planned urban PRT, as a competency of the built environment, could offer an important next step or perhaps even a paradigm shift in the evolution of transportation systems for dense urban environments helping to minimize the impacts to the environment, while providing a highly reliable and safe standard of personal mobility for all users.[2] The paper will use examples from the MASDAR program to discuss in more detail, the planning process and factors used for the MASDAR system as perquisites for system selection, and the competencies and technologies of Personal Rapid Transit, as they are intended for MASDAR City.[3] The paper will then extend that discussion of PRT technologies to competency contributions of the traditional modes of transport, as outlined in Figure 1. The paper concludes with some thoughts on how the technologies of PRT have the potential to rapidly help make dense urban environments more sustainable while enhancing personal mobility.

Planning Factors for PRT

In understanding when PRT is an appropriate mobility technology one must consider many factors. Per capita density of the intended or existing built environment is one of the most important. Intensity of development generally reflects the per capita per acre which is the core of the challenge – how to provide personal mobility for large numbers of people efficiently, and taken a step further today, in a sustainable manner. The higher the intensity of development, the larger the number of people who have mobility needs. Most systems today use a public approach versus a personal approach (largely the current purview of taxicabs and automobiles) as a means of achieving the efficiencies needed for capital costs and space use. Yet we see in many of the world's most dense urban environments a very high and unrelenting demand for personal mobility. This brings to light the mobility dilemma facing the world today.[4] Mobility needs must be addressed on both the public and personal scales.

At the macro scale, the World Business Council for Sustainable Development's (WBCSD) assessment is that the world's mobility needs trajectory is unsustainable. New technologies are needed to meet the mobility needs of today and the future. They further assert that to solve tomorrow's mobility needs by mid-century, contributions from all stakeholders will be required. Accordingly, the technology of urban PRT can be a key contributor as outlined above. Rather than looking to each industry sector to contribute within its own traditional parameters, we can look for the best and most relevant competencies from each to form a new approach that can allow the blending of public and personal on-demand mobility and add sustainable mobility solutions.

Transportation (Mobility) Goals and System Boundaries

An important first step in the technology of the PRT is establishing the desired end state as a performance outcome or goal. All too often, the basic planning and goal setting start with the mobility technology(s) as givens. This approach places significant constraints on the development of truly innovative means that can lead to the sustainable mobility solutions needed. The history of PRT is replete with many attempts to solve mobility problems with abject rejection of PRT as an invalid and unachievable mobility technology. Today however, the drivers of a new global sense of urgency, technical understandings and tools to fully integrate the contributing core competencies of PRT are present and available making it possible to achieve large scale PRT deployments. Until now, the missing elements have been the vision, leadership, and financial structure to build the first one. This is why the goal setting set is so crucial. Without a clear vision of the desired end state and the courage of the planners to pull it all together, it simply will not happen. The inertia of the past and the comfort of the known are difficult to overcome.

The PRT planning for MASDAR City undertaken by Fosters & Partners in collaboration with Systematica SpA is an example of how important the goal setting can be. The MASDAR PRT vision began with a carefully developed structure of goals, a system concept and guiding principles.[5] The overarching and sustainable mobility goal for MASDAR is:

> "Create a prototypical and sustainable "built environment" where residents and commuters can live, work, and recreate without the need for a personal fossil fueled vehicle, essentially, a zero carbon environment. Without the daily need for personal vehicles, the city has opportunity to operate on a model that avoids carbon dioxide emissions, noxious gases, and provides a safer pedestrian and human friendly environment while reducing resident carbon footprints which contribute to global warming."

Careful consideration of several alternative mobility technologies led the planning team to a combination of multiple modes of mobility as one way to achieve the goal. Using a high level origin and destination demand modeling approach the planning team formed the fundamental internal and external access requirements around a designated system boundary.

System boundary setting is a very critical yet sometimes overlooked aspect of sustainable planning, and it is vital to the technology of sustainable mobility planning. Consider the concept of mobility as a complex system of interdependent activities. The confluence of the system activities allows the system to be measured and managed. Like many systems engineering challenges, the interdependencies of the components will largely determine the effectiveness and efficiency of the overall system. Thus, a system boundary, the perimeter of the city, was a critical requirement for the MASDAR mobility planning. Most mobility activities within the system boundary would be measured and managed by MASDAR. Mobility activities transcending the system boundaries would be shared management, and activities beyond the system boundary require a set of aligned stakeholders, including MASDAR, to measure and manage the system performance outcomes. The MASDAR mobility system planning boundaries are shown in Figure 2. The large three-dimensional square represents the system boundaries for the MASDAR internal access requirements. The lowest (red) network is the PRT system, which extends to the external car parks. Other lines represent the roadways, the planned Light Rail Line and the Regional Train Line. The highest (green) network is the pedestrian system.

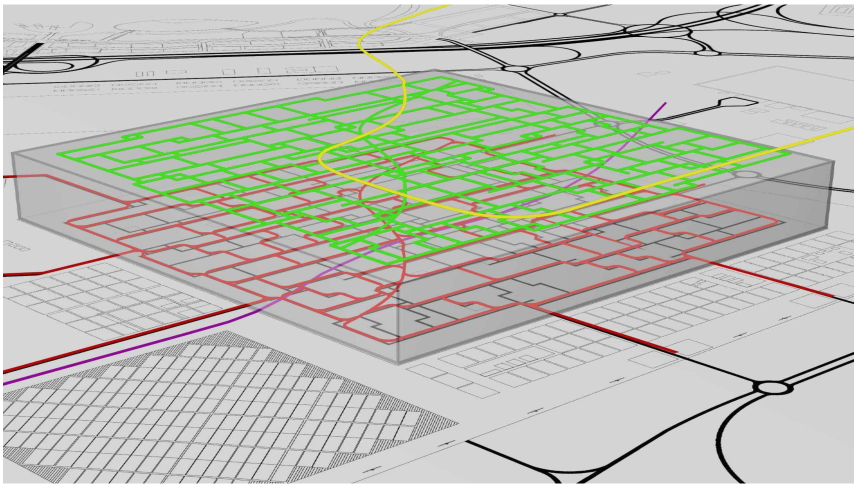


Figure 2. MASDAR Mobility System Layers and Boundaries

The establishment of the mobility system boundaries also requires the identification of potential mobility stakeholders early in the planning. Depending on the systems used, these stakeholders can include all modal users, all system providers and operators (public and private), proximity stakeholders, governance bodies, government officials, civil defense, safety and security communities. Each stakeholder can bring important understandings and perspectives to the planning and all should have a clear purpose in their participation. While unique in their individual interests and concerns, they also share a common responsibility and that should be a strong alignment to the mobility planning goals, the basic system concepts and intended planning principles. Establishing the collaboration of the stakeholders is the transportation planner's and system designer's responsibility.

Transportation System Concept

Once the fundamental goal(s), system boundaries, and stakeholders have been identified the process of alternative mobility concept development and evaluation should begin. The mobility concepts for dense urban environments will necessarily be complex requiring an approach that continually challenges the alternatives being considered with the goals or end states that have been set. Unlike the goals, the mobility concept alternatives should be developed with flexibility as a key attribute. Integrating the underpinning competencies, with the exception of system safety, will require significant effort in the form of attribute and performance trade off, cost benefit, and life cycle cost analysis to truly understand and integrate the competencies needed for a successful concept and sustainable system design.

To illustrate this point the MASDAR mobility concept and competency integration took the shape of vertical diagram versus the typical two-dimensional system map. The integrating competency is actually the built environment, which forms the physical means to achieve the desired end state.

Shown in Figure 3 as a typical cross section of MASDAR, the ease of access to each component of the overall mobility system is accomplished in a vertical plane, and further reinforces the point that the alternative concepts should look to a very high degree, and sometimes quite unique integration of the contributing industry group's competencies. In the case of MASDAR, the built environment provides the strongest integrating platform for the rest of the system competencies.

Beginning at the bottom, the regional train line (underground) is the principal access mode for residents and commuters traveling within the region with connecting access at their point of origin. Moving up, the next components of the system are the personal rapid transit, the material rapid transit, and the waste transit, which operate as one system and replace the cars and trucks of typical cities for internal citywide access. This system is a key component of the city planning as a trade off decision was taken early in the master planning to construct an "undercroft" to house the system thus ensuring physical separation from pedestrian and bicycles on the "podium" level above it.

Additional external access from more local origins will be by way of an elevated light rail train (LRT). Operating above the pedestrians and bicycles, this system will connect MASDAR City, the adjoining communities, and the Abu Dhabi International Airport. It also serves as the principal means of local commuter access. Yet to be decided, but still allowed in the concept development is another form of PRT, an "elevated express PRT." The idea behind this component of the system's concept is to bridge the availability of the LRT system with local external access operating on an express concept with fewer stations than the dense PRT network operating in the undercroft and helping to ease a yet to be confirmed detailed system wide origin and destination demand model.

Each of these components brings both technical and fiscal opportunity and risk to the mobility concept selected. The integration and ridership models are being developed around a business case based model, which operates within a market-oriented strategy of regional and local mobility.[6]

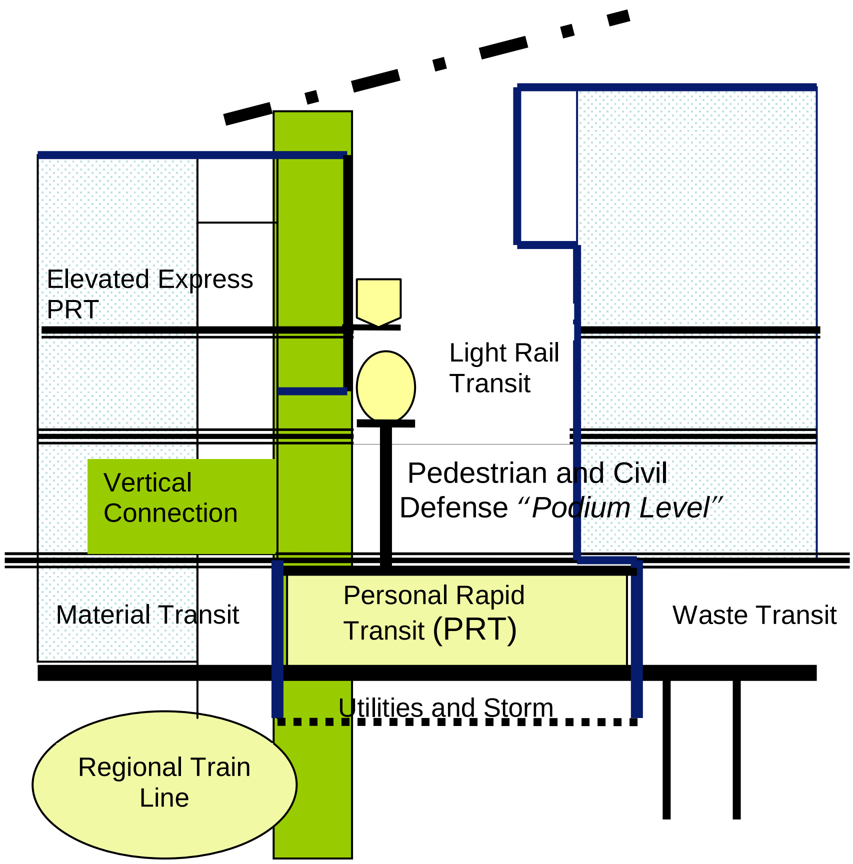


Figure 3. Sustainable Transportation Concept – MASDAR City

Stated as a sustainable mobility concept, the MASDAR sustainable transportation system concept integrates pedestrian, public modes, and a revolutionary automated private method that uses multiple levels to safely move people, goods and provide services in an efficient and barrier free environment.

Clearly and articulately, the alternative mobility concepts allow the system planners, designers, and stakeholders to identify the points of alignment and the issues that need to be resolved. As an example, in the case of MASDAR, the question of safety certifications for the PRT system immediately surfaced. Unlike the highly regulated automotive competencies, the Abu Dhabi Department of Transportation (DOT) will need to establish a clear line of authority as a regulatory entity over a private system operating on a private infrastructure. Their policies were simply silent. The rail and transit industry group however does have much clearer lines of authority for such systems and the safety competencies aligned much clearer with that industry group. It is precisely this level of goal focused integration, stakeholder involvement, and issue resolution that allow the innovation needed for tomorrow's sustainable mobility solutions to move from the drawing table to reality.

Transportation (Mobility) Planning Principles

The last step in the planning for PRT technology is the most difficult because it requires the planners, system designers, and stakeholders to begin to resolve the many tradeoffs inherent in the planning and the integration of the components. Additionally, the development of the system's guiding principles requires the planners to begin to articulate the way the system(s) will be measured and managed well before the details are known. Like many other disciplines, the age old adage applies - what gets measured gets done. While not yet to the point of defining the system's metrics, the principles tell the planners, designers, and stakeholders if their decisions that take their concept to the next step of design development are the right ones to ultimately achieve the goal or desired end state. The principles become the elements of truth for guiding the system's creators in their design and deployment decisions. When the design development decisions need testing, the principles become the anvil of truth and the guarantee of success. As such, they are perhaps the most important aspect of the overall PRT planning technology. Without the truth-tested basis of the system's performance, the planning is without purpose, and the goal(s) will not be realized.

The planning principles should be logical and technically connected statements that are clear representations of the system concept each of which gives meaning and depth to the stated and agreed system goal. Continuing the example of MASDAR, the concept system was tested against eight guiding principles shown in the table (Figure 4). The mobility planning principles reflected the sustainability, low carbon, and car free precepts of the mobility goal. Each principle should be easily developed into meaningful metrics that when taken as a set allows one to measure objectively and/or subjectively assess the system's intended performance.[7]

Principle	**Measurable**	**Objective**	**Subjective**
Provide quick and efficient modes that are fully integrated in time and space	**Yes**	√	
Ensure safe, secure, and barrier free modes are available 24/7 to all residents and commuters	**Yes**	√	
Respect cultural privacy in a way that public transport does not	**Possibly**		√
Provide full access to transportation system within a short walking distance	**Yes**	√	
Provide an expansion-ready, and technology upgradeable approach to implementation	**Yes**	√	
Provide a sustainable system that serves the users' needs fully	**Yes**		√
Provide a system that strongly reflects healthy living lifestyles	**Possibly**		√
Implement travel demand management measures to promote positive travel behavior	**Yes**	√	

Figure 4. Planning Principles – MASDAR Mobility System

Within the principles for the MASDAR mobility system, the planning for it as a sustainable mobility system is deeply integrated in the alternative concept development largely because it was planned from the beginning as a new system for a city yet to be built, and because PRT has the inherent requisite components to be sustainable set of technologies. There are equally valid and more generic planning principles that can guide the application of the urban PRT as an alternative mobility concept for existing cities.[8] These more generic planning principles are based on the traditional delivery metrics commonly associated with major projects and programs, but are extended to take into account the fundamental attributes that can help plan the system as a sustainable solution. To be responsive to the world's future mobility needs, the authors of the Mobility 2030 Project encourage the mobility planners to embrace a new paradigm in their planning as well as new technologies such as PRT.[9] They advance such ideas as car sharing which is a fundamental operational parameter of the urban PRT, except that it is offered as a driverless taxi operating on a planned network. In planning the development of sustainable mobility systems for the future, the paradigm shift offered by Dr. Jorge Vanegas, and shown in Figure 5 is a useful starting point. To be successful today and for tomorrow, all mobility systems must deliver on the traditional measures of project performance – schedule, cost, and quality. In solving tomorrow's sustainable mobility problems, more is expected and more must be delivered. Based on an extension of the universally accepted World Commission on Environment and Development[10] framework for sustainable development, the model suggests that for a mobility solution to be sustainable it must also address environmental, natural resource base conservation, and societal needs far better than past mobility solutions.[11]

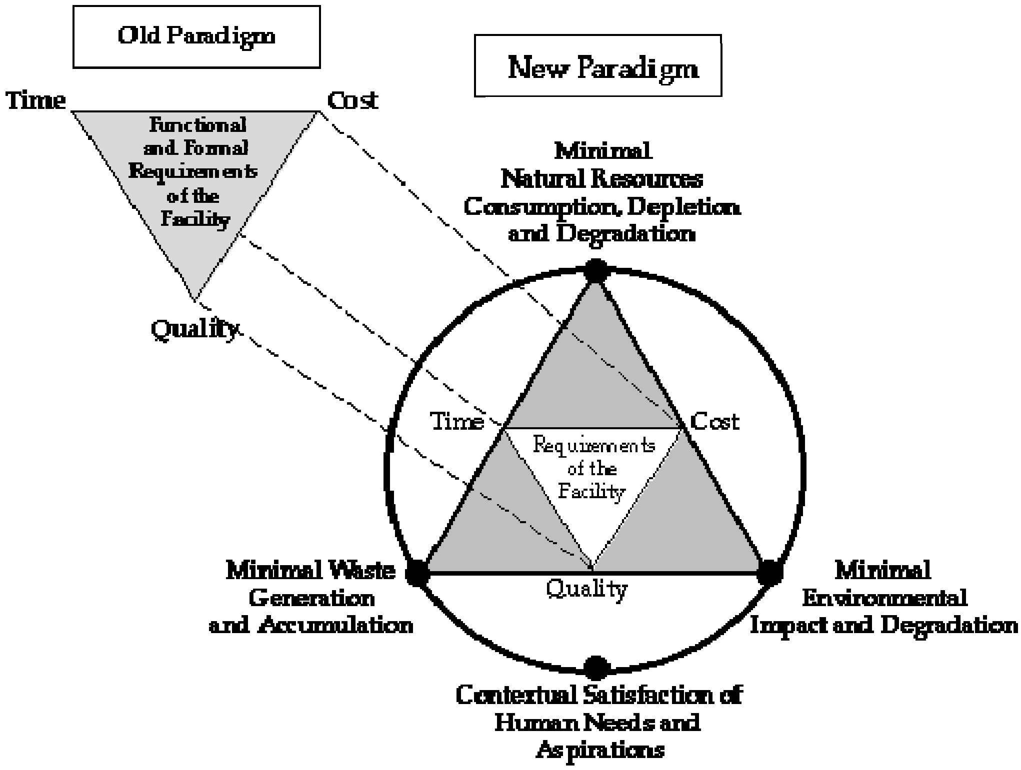


Figure 5. The Vanegas Conceptual Model for the Delivery of Sustainable Solutions

Regardless of the challenge at hand, this infrastructure based model serves very well as the basis for building a meaningful framework of principles to measure the planned performance of an urban PRT solution. Further, this model is easily adapted to most if not all sustainable mobility planning needs.

To summarize, as perhaps a universal practice approach to urban PRT planning, the planning technologies and process must be based on a sustainability framework that addresses the regional needs as well as the global issues. Accordingly, successful sustainable mobility planning must begin with a well-articulated vision and goal statement. This goal must be universally held by the complete set of planners, system designers, users, and a multitude of internal and external stakeholders. The planning must consider multiple alternative mobility concepts while remaining flexible to encourage innovation for sustainability. The planning should measure all alternatives and especially status quo mobility approaches with respect to the value and contribution they are making as mobility systems and as world-class sustainable solutions. Lastly, the mobility solutions should look to converge uncommon competencies among the traditional modes of transportation, and the built and natural environments for paradigm shifting and sustainable solutions.

The next three sections of this paper explore the competencies and technologies of the traditional modes of transport (automobile, aviation and rail/transit) and relate this discussion of the built environment competencies highlighting their technical contributions to sustainable mobility solution set development and the technologies of urban PRT.

Automotive Industry Competencies as they Relate to the Technologies of PRT

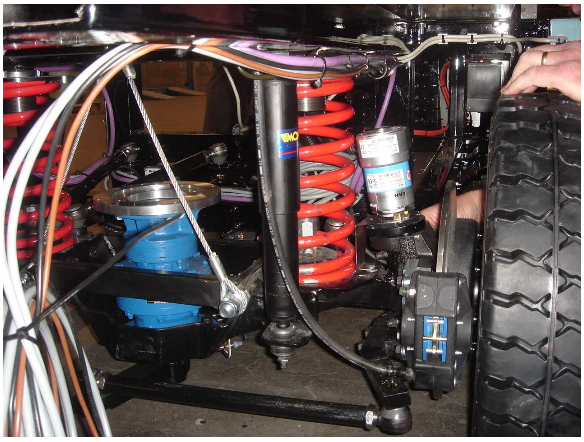
The automotive and rail sectors both serve as the basis for the vehicular-based development of PRT. The automotive sector's differentiating factors are found in its ability to operate without a visible physical track, rail, or guide way. Additionally, the similarity of a rubber or soft wheeled bus, automobile, or truck adds to its initial social acceptance as being more similar to an automobile or truck, experience than an amusement park ride. Adding to the soft wheeled vehicular approach are the rapidly evolving technologies of remote control and autonomous vehicle (driverless) operations. The informational and computational technologies of driverless or automated driving are rapidly advancing. Recently, there have been several industry members announcing multiple technical breakthroughs in the driverless operations.[12] These technologies, many of which were sponsored by the (US) Defense Advanced Research Project Agency (DARPA) have direct applications to the vehicular based PRT and bringing the technologies of PRT one step closer to its ultimate large scale potential.

For MASDAR, the initial Phase 1A PRT technology uses a roadway based infrastructure and a wheeled driverless vehicle. This phase of the program is being procured as a test phase with approximately two kilometers of roadway surface and 13 vehicles. The prototype passenger vehicle is shown in Figure 6.

Figure 6. MASDAR Phase 1A Prototype Passenger PRT

Moving from the prototype stage to a larger scale deployment will require a developmental approach to overcome the many technical and fiscal challenges. Under consideration as an approach to meeting this need is the identification of an interested information technology or mobility system integrator as a partner for MASDAR.

The automotive industry also contributes significant technologies in the form of chassis development and manufacturing. Using many standard components of automobiles such as electric motors, batteries, tires, axles, wheels and body components, the automotive sector possesses all of the needed competencies to efficiently design and manufacture these types of vehicles. Shown in Figures 7 and 8 are components of the prototype for the basic chassis of the Phase 1A system.



Figures 7 and 8. MASDAR Phase 1A Chassis Prototype "Workhorse" and Suspension Systems

While important to and perhaps the most visual aspect of PRT for most people, the most significant challenge is the development of the supervisory control systems needed for large scale operations. Since the initial commissioning of the West Virginia University System in the 1970's many companies have explored and advocated the development of PRT as a future mobility technology with only a few making it past small scale deployments.[13] It is only within the current lens of sustainability and the significant future mobility issues as outlined by the WBCSD that a renewed interest has developed in overcoming these challenges.[14] Coupled with the revolutionary development of information technology, precision locating systems and advanced communications the confluence of need and competency now makes the push for an urban PRT technology an achievable and desirable sustainable mobility solution.

The automotive industry has much to contribute to both wheeled and tracked PRT. The mechanical, control and propulsion competencies developed over the last century are needed for the successful integration and large scale use of urban PRT. The next section addresses the aviation industry and their potential contributions to the technologies of urban PRT.

Aviation Industry Competencies as they Relate to the Technologies of PRT

The confluence of advanced technologies across many industry groups is perhaps nowhere more visible than in the aviation sector and specifically that of military aviation research and development. One of the earliest documented interests in PRT actually developed from the technical curiosity of Dr. Jack Irving, who was involved in a program of research in 1968. At that time, Dr. Irving was associated at the Aerospace Corporation of El Segundo, CA[15] and later became one of the most noted visionaries in the field of PRT. Today the parallel technology interests continue with a rapidly evolving unmanned aero vehicle program in full scale deployment and approach in second generation development. The complex technologies of aviation closely parallel the needed technologies for large scale urban PRT. They are particularly transferable in the areas of precision navigation, and location sensing, real time instantaneous communications, network management and operations, and control and collision avoidance. Digging deeper into the safety concerns, the technology redundancy competencies of the space program and unmanned flight are directly related to some of the issues facing large scale urban PRT applications.

These are the parallel and needed competencies, that when imported for the development of urban PRT, make it possible to operate the scale of systems needed for commercial viability. Figure 9 provides a high level assessment of the aviation and information technology competencies needed to drive the advancement of PRT to an urban scale.

Supervisory Control System Competency Needs	Level of Development	Near Direct Application	Indirect or Parallel Application
Precision Location System	Mature	√	
Real Time or Near Real Time Communications	Mature	√	
Complex Network or Mesh Network Management	High	√	
Remote Precision Controls	High	√	

Supervisory Control System Competency Needs	Level of Development	Near Direct Application	Indirect or Parallel Application
Remote and Local Collision Avoidance	Mature		√
Local Object Detection	Mature		√
Autonomous System Fault Correction	High		√
Artificial Intelligence	Medium		√
Six Sigma System Reliability	High	√	
System Wide Redundancy Design	Mature		√

Figure 9. Aviation Industry Competencies as they Relate to Urban PRT

The set of near direct application competencies could be combined and adapted for a large scale PRT network to form the fundamental communications and control logic and system. The indirect or parallel competencies could be adapted to create the reliability, system efficiency, and safety backbone that are needed for wide scale acceptance.

Earlier in the planning for the MASDAR PRT, the planning team struggled to envision a way to upscale existing control technologies for an urban scale. In fact, this has been the principle challenge along with significant capital costs over the history of PRT advocacy. Like many mature technologies, they are inherently limited in scale. Adapting an existing "in sector" technology, while a much lower risk, will not upscale well. Adapting unlike technologies from different industry sectors for similarly complex applications has much more potential and does not generally have the inherent limitations of scaling up. In more specific terms, future urban PRT control technologies will be more like than unlike the MASDAR citywide system. Shown in Figure 10 as a network, the MASDAR system is a series of single direction travel loops connecting approximately 83 passenger stations to achieve the desired service levels.

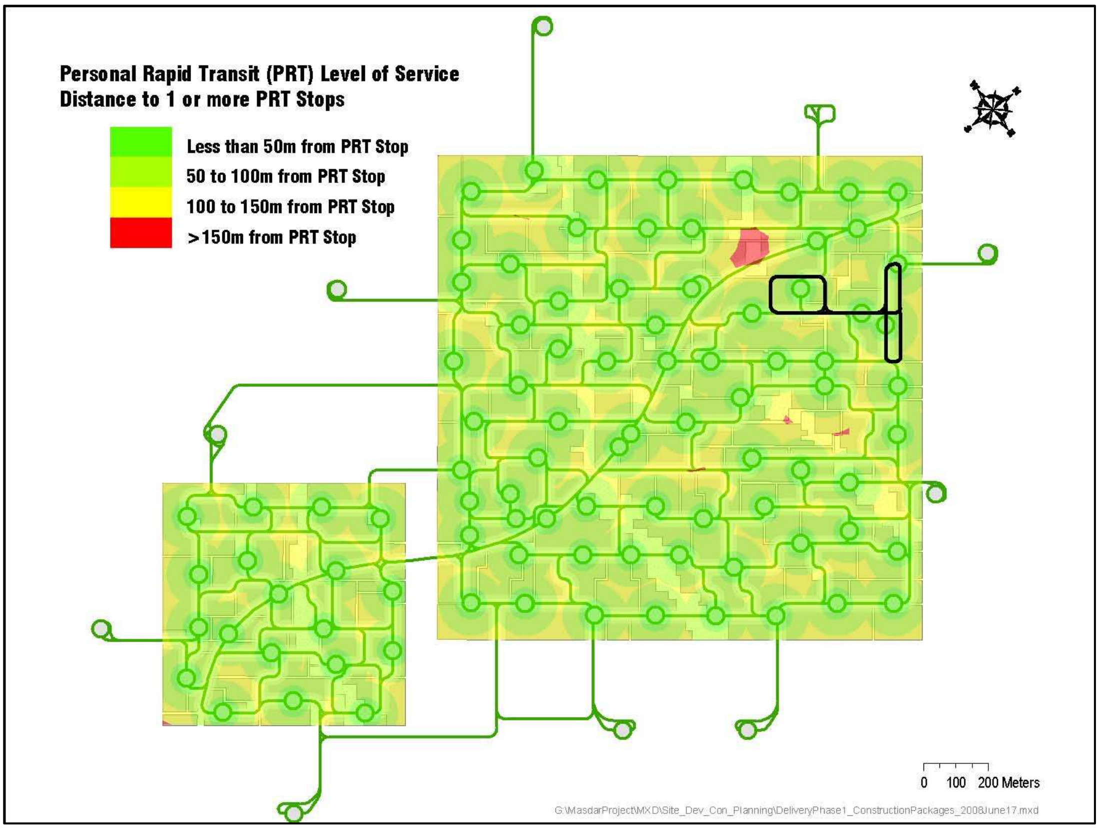


Figure 10. MASDAR Citywide PRT Network

The heavier line in the top right corner of the network is the phase 1A test system. This test system is comprised of 13 vehicles, (ten passenger, two freight, and one refrigerated vehicle), two passenger stations and two freight stations, 1,700 meters of roadway and the supervisory control system. This test phase will function as both an active service system and a developmental system allowing the delivery team to better understand the technology interface and integration challenges for the citywide system.

In forming the procurement strategy for the MASDAR citywide system, the program team interviewed multi-national aerospace, aviation, defense contractors, and information technology corporations. In each interview, the complexity of the needed supervisory control system was seen as a challenge, but not an unachievable technical outcome. Clearly, there is a lot of work to do and a lot of upside opportunity once it is accomplished. Confidence within the team is high that they will be successful in mastering this vital and paradigm changing aspect of urban PRT. The fundamental research for the basic components exists. Adapting, assimilating, and integrating it all as a supervisory control system is the technology task at hand.

Rail and Transit Industry Competencies as they Relate to the Technologies of PRT

The difficult, perhaps even problematic history of PRT, has not escaped the rail and transit industry for understandable reasons. The rail industry as a mature set of technologies has one of the longest and most intense research, development, testing, and validation protocols. This industry attribute when viewed as both a strength for its results and a less desirable quality for innovation can and should be the basis for the safety and reliability dimensions needed to drive the urban PRT technologies forward and ensure the operational performance meets the public expectations. There can be no compromise when the technologies of safe and reliable design and operations are at stake. Accordingly, the rail and transit industry has a vital contribution to make to the development of urban PRT technology. There is however, a need for the embedded prejudice that exists today to be set aside. Solving the global 2030 Mobility needs as outlined by the WBCSD requires a fresh approach to the technologies and utility of PRT and the long standing and enviable rail and transit competencies are easily transferable for urban scale PRT. Many of the current PRT technologies are actually very much like their rail and transit predecessors differing only in their public versus private ridership concepts.

The fundamental principles that guide the planning and design of rail and transit have application for PRT. Technologies like fare systems and ticketing, rail and track design and maintenance, station design and accessibility are all parallel technologies with direct application as well as system safety and reliable operations. All of the PRT suppliers today have developed some form of track, pathway, guide way or rail network for their vehicles or pods to operate. These same suppliers have had to think through the complex planning and design considerations to make their system concepts acceptable. Using the vast history of the rail and transit industry to improve and perfect these concepts can be a huge contribution to the urban PRT as a sustainable and useable system. To elaborate, the PRT stations shown in Figures 11 and 12 are similar in many aspects to metro and small scale subway stations today. The fundamental difference is scale. Rather than sized for public mass use with entrance and exit requirements orders of magnitude larger, the PRT stations must have the same functionality but only for small numbers of passengers at any one time. Adapting the rail and transit technologies to PRT can clearly be a huge contribution to advancing the technology of urban PRT.

Figures 11 and 12. PRT Station Concepts – Courtesy of ULTra and Taxi2000*

The MASDAR mobility concept discussed earlier is actually a combination of public external access by both rail and transit and private internal mobility (PRT) for distances greater than 150 meters. Accordingly, the system safety, reliability, access, and ticketing functions must work in a seamless and integrated way. This would be largely true for any urban application. Lastly, and perhaps the most vital aspect of technology transfer for the rail and transit industry is in the area of demand modeling and ridership requirements. The envisioned MASDAR citywide PRT system will not function efficiently if the operational requirements among the modes are not well integrated and operationally managed. Demand modeling accordingly, becomes a critical interface point for the entire mobility concept.

In summary, the rail and transit industry technology interface with PRT is a vital and compelling developmental need for realizing urban PRT at a large scale. The contributions the industry can make are extensive and range from fundamental safety to passenger ease of access. One additional thought, these industry groups are not in competition today, and do not need to be in the future. Millions of mobility decisions are made across the world every hour of the day. These decisions are based on many variables that the resource base of the future cannot sustain. Planning for tomorrow's sustainable mobility will require all transportation professionals and providers to work together to create the greatest possible capacities to move people and goods.

Creating a Sustainable Future – Mobility Systems

The past advocates of PRT likely saw the technology as visionary mobility solution, probably thirty years ahead of its time. Today, the advocates of PRT are likely to be joined by a concerned global population that believes our lifestyles and resource needs, especially in western society, are greater than the resources available to meet them and that there is not an endless and immediate renewable set of resources available to continue. This unsustainable situation is further highlighted with a new awareness of climate change and the environmental implications that are just now beginning to be understood. Today's transportation systems have near parity with the built environment in the green house gasses they produce across the globe. The need to bring low or no carbon mobility solutions forward is huge. When compared to the built environment efforts today, be it renewable energy, green buildings, green infrastructure, or any other facet of the built environment, the community of professionals is on the move and delivering the innovation needed to begin to create a truly sustainable built environment. Our transportation and mobility community must rapidly ramp up its efforts across all of its vast industry sectors to meet the challenge of 2030.

One must believe that finding the technical solutions to meet the mobility demands of today without compromising tomorrow's mobility needs is possible. The only question that remains is do we, as a mobility community, have the will to do it. Urban PRT as an alternative personal form of mobility presents some truly innovative and sustainable potential for solving mobility needs of the future. The challenges, and there are many, can be overcome with the right leadership, the right vision, and the right collaboration across industry and government.

One final note: To the "fathers" of PRT and their many followers, thank you for your "gift" to us. JM

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*Taxi2000 Presentation to MASDAR – used with permission. D.S. Altrowitz

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