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Comparative Analysis of Personal Rapid Transit System with Thermoplastic Material for Interconnecting Metro Station with Airport

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Abstract

Personal rapid transit (PRT) systems open a slew of new possibilities for solving airport-related transportation issues, both on the ground and in the air. For use in airport applications, the advantages and disadvantages of this mode of transportation are contrasted. An implementation of the ULTra Personal Rapid Transit system to assist passenger and staff vehicle squares at Heathrow is used to showcase the work. The ULTra infrastructure's compact size and flexibility allow it to utilize tunnel side bores and integrate with the complex central terminal area in an unexpectedly straightforward manner. In comparison to present buses, detailed comparisons demonstrate a reduction in travel time and a reduction in operational costs. The glass/polypropylene face sheets were produced using a single diaphragm forming procedure. Microstructural examination of the face sheets proved that this method produces excellent consolidation. The face sheets and core material were adherently joined and tested to verify the model. The body panel failed due to an adhesive failure when the stress reached 11.7 kN. The American Public Transportation Association's requirements for the body panel's static loading were met. A traditional bus with an aluminum covering and supporting steel bars showed excellent weight savings of more than 55% as compared to the thermoplastic composite body panel. The research demonstrates that such modes of transportation are ideally suited to land-side airport uses. A summary of potential benefits for airside operations is also provided.

Keywords: Urban transportation, personal rapid transit (PRT), pod car, ULTra PRT, intelligent transport system, thermoplastic materials

INTRODUCTION

Personal rapid transit (PRT), commonly referred to as a pod car, is a form of public transportation that makes use of small autonomous vehicles that travel over a system of specially designed guideways. PRT falls under the category of automated guideway transit (AGT), which encompasses everything from massive vehicles to modest subway networks (Figure 1). PRT is designed for individuals or small groups, with each vehicle carrying 3 to 6 passengers at most. All stations are located on sidings, and there are several merge/diverge junctions across the network structure of the guideways. This makes it possible to go nonstop from point A to point B without using any intermediate stations. One person compared the point-to-point service to a cab. Most public transit systems operate along pre-planned routes and carry passengers in groups. It is not perfect [1–3].

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Time is wasted by passengers waiting for the next train, making detours to get there, pausing for others who are going somewhere else, and navigating frequently unclear or erratic schedules. Huge items moving slowly or quickly can impair the environmental advantages of public transportation while also slowing down other cars. A PRT system attempts to eliminate these shortcomings by transporting small groups of people in automated vehicles on predetermined tracks in an unending loop. Travelers must be able to board a pod as soon as they arrive at a station, and if the rail network is large enough, they should be able to travel directly to their destination without stopping.

Figure 1. An ULTra personal rapid transit (PRT) vehicle [1].

Manufacturing of Thermoplastic Body Pan Segment

A body panel in cross-section showing the pan portion created. It has exterior and inner face sheets made of glass/polypropylene (PP) woven tape, a PP honeycomb core inside the pan portion section, and polyurethane (PU) foam stuffed inside the cavity. Hot-melt glue was used to bind the face sheets to the PP honeycomb core. The following are the procedures for creating the body panel: Making the glass/PP tape and weaving, making the interior and exterior face sheets, bonding the honeycomb core to the interior panel, filling the rounded corners with PU foam, and bonding the exterior flat panel to the interior panel and core are all examples of steps in the manufacturing process (Figure 2). The core is machined to match the shape of the pan cavity [2].

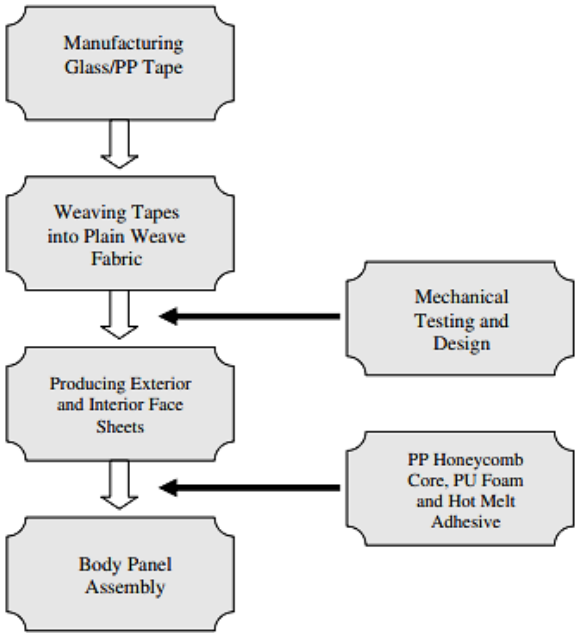

Figure 2. Steps of manufacturing of thermoplastic body pan segment [2].

By using a hot-melt impregnation procedure, glass/PP tape with a fiber content of 67% weight (42% volume) was created [4, 5]. An outside source shaped the tapes into a plain weave architecture. The plates made from four layers of the glass/PP tape had their mechanical parameters, such as tensile modulus and strength, flexural modulus, and strength, tested. At the bottom chamber, where the woven tape was placed, an 85 kPa vacuum was applied. Along with the vacuum pressure, high-pressure air was pumped into the top chamber to create a pressure of 344 kPa, which was used to apply a consolidating force to the prep-reg through the flexible silicone diaphragm [2].

STUDY AREA

Airport Metro Station, Nagpur (21.08720, 79.06342) to Dr. Babasaheb Ambedkar International Airport, Nagpur (21.09028, 79.05463) situated 8 km southwest of city part of Nagpur (Figure 3).

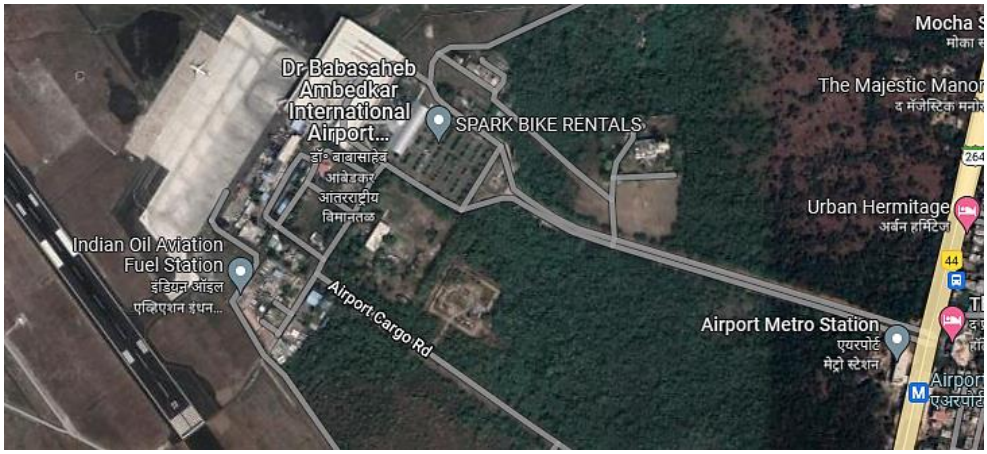

Figure 3. Study area.

METHODOLOGY

The methodology for comparative analysis of PRT system is as follows. The identified parameters and factor for comparative analysis of personal rapid transit system are feasibility, safety, level of comfort, level of service, time consumption, capacity, and revenue [6]. After collecting data for each parameter, the comparative analysis between existing service and PRT system was done. After analysis, results were calculated and conclusions were drawn (Figure 4).

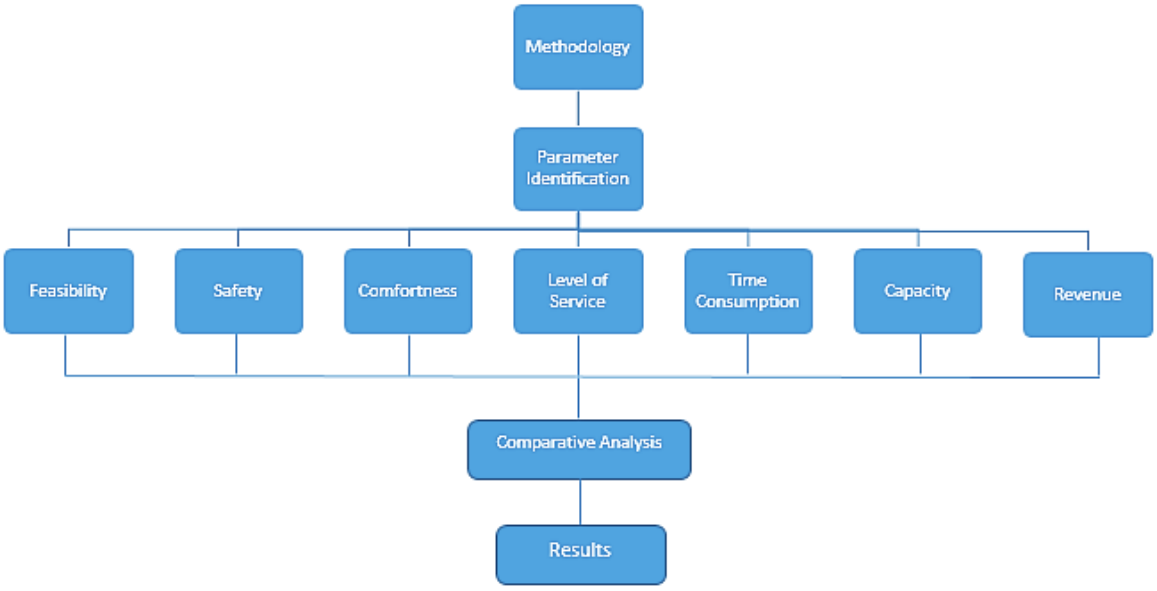

Figure 4. Flowchart of methodology.

DATA COLLECTION

Feasibility

Operational Feasibility

Operative feasibility of shuttle bus service and PRT system is compared. The parameters such as headway, speed, average occupancy, average trip length, and route length were evaluated. To compare parameters, difference is calculated of each parameter [7, 8]. The data of shuttle bus were collected from the Nagpur Municipal Corporation (NMC) transport department. The difference between headway is nearly 4.5 minutes, speed difference is 15 km/h, average occupancy is 28.7, while the average trip length and route length difference is same (Table 1).

Table 1. Operational feasibility for existing shuttle bus services and personal rapid transit (PRT) system [1]

	Shuttle Bus Service	**PRT System**	**Difference**	**Shuttle Bus Service**
Operational	Headway	5 m	3 s	297 s
	Speed	45 km/h	30 km/h	15 km/h
	Average occupancy	32	3.3	28.7
	Average trip length	2 km	2 km	0
	Route length	2 km	2 km	0

Safety

One of the primary causes of unintentional deaths worldwide is traffic accidents. Any misalignment on the road is dangerous for the driver, the vehicle, the business, and the client. The accident data were collected near Nagpur airport from 2015 to 2021. The data were collected in three parts: number of accidents, number of deaths, and number of injured of each mode of transport near Nagpur airport. The data were collected from DCP traffic police office as well as NMC transport department [9, 10]. The data indicate the safety of passenger and PRT system having zero number of accidents (Table 2).

Table 2. Accident data for existing services and personal rapid transit (PRT) system

Nagpur Airside accident Data 2019-21				**PRT Accident Data 2019-21**			**Difference**		
	Accident	***Death***	***Injured***	***Accident***	***Death***	***Injured***	***Accident***	***Death***	***Injured***
2015	5	1	8	0	0	0	5	1	8
2016	6	2	7	0	0	0	6	2	7
2017	4	1	5	0	0	0	4	1	5
2018	5	1	6	0	0	0	5	1	6
2019	6	3	9	0	0	0	6	3	9
2020	1	0	2	0	0	0	1	0	2
2021	4	2	6	0	0	0	4	2	6

Level of Comfort

The experience of transportation passengers must include comfort. Crowding can dramatically reduce passenger comfort, impede the delivery of services, and discourage people from using public transportation. The data were collected from the survey of passengers of shuttle bus service that connects airport metro station to airport. After collecting data from passengers, it was divided into three parts: comfortable, uncomfortable, and extremely uncomfortable. The parameters considered are seat types, maintenance, travel time, air condition, air quality, lighting, and visual comfort. Most of the passengers and staff of airport had issues with existing service regarding timing, fare, condition of vehicles, etc. The data showing passengers' review is presented in Table 3.

Level of Service (LOS)

To link the standard of traffic service to a specific flow rate, a concept known as level-of-service (LOS) of a traffic facility was developed. The Highway Capacity Manual (HCM) proposed the term "Level-of-Service" to describe the standard of quality that can be obtained from a location under

various operation parameters and traffic volume. HCM defines LOS as a letter that specifies a variety of operational circumstances for a specific type of facility. HCM defines six LOS letters, A through F, with A representing the highest level of service and F representing the lowest. These definitions are based on the facility's effectiveness measures. Speed, travel time, density, delay, and other metrics are commonly used to assess effectiveness. Each LOS level will have its own service volume. A service volume or service flow rate is the maximum number of cars, passengers, or the like that can be accommodated by a specific facility or system under specific conditions at a specific LOS (Figure 5).

Table 3. Comparison of level of comfort between shuttle bus service and personal rapid transit (PRT) system

Level of Comfort Parameters	**Shuttle Bus**	**PRT System**
Types of seat	Uncomfortable	Comfortable
Maintenance	Extremely uncomfortable	Comfortable
Travel time	Uncomfortable	Comfortable
Air condition	Extremely uncomfortable	Comfortable
Air quality	Comfortable	Comfortable
Lighting	Uncomfortable	Comfortable
Visual comfort	Uncomfortable	Comfortable

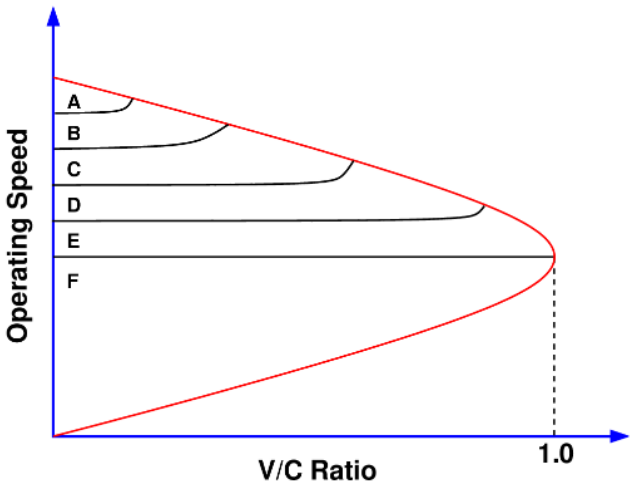

Figure 5. The operating speed and volume to capacity (V/C) ratio are used to express the level of service of the mid-block section [3].

The following numbers can be used as the facility's capacity because such a facility is regarded as ideal:

- A lane's capacity is 2000 vehicles per hour at 115 km/h.
- A speed of 80 km/h and a capability of 1900 automobiles per hour per lane.
- 2800 vehicles per hour, in both directions, at 100 km/h.

The above-mentioned values were statistically determined from the measured field values from numerous similar sections, not analytically or experimentally. It is crucial to note that a stream larger than this volume amount is conceivable but not essential. The aforementioned capacity values *decrease* as a result of numerous "non-ideal conditions," such as adjustments to travel time or speed, traffic restrictions or disruptions, etc. As a result, HCM has established multiple service levels for the traffic facility. Several user questionnaires that capture drivers' perceptions of the features of the transportation under various working conditions are used to assign a quality value. The various operating situations and the Level-of-Services (A to F) are shown along with the service quality in Table 4. After calculating, the level of service for PRT system is LOS A [3].

Table 4. Mid-block section level of service [3]

Level of Service	Quality	Speed (km/h)	Volume/Capacity (V/C)	Description
A	Free flow	80	0.6	Physical and psychological convenience on a high level
B	Reasonable free flow	70	0.7	An acceptable level of physical and psychological convenience
C	Near free flow	60	0.8	Local deterioration possible with blockages
D	Medium flow	50	0.85	Non-recoverable local disruptions
E	At capacity flow	40	0.9	Minor disturbances resulting breakdown
F	Congested flow	15	1	Breakdown of flow capacity drops

Time Consumption

The proposed system's cost and performance were also compared to the current shuttle bus services to the parking lots. NMC provided precise bus schedules for the employee parking lots as well as an overall cost estimate, but commercial confidentiality prevented further cost information from being provided. The service at the bus stop is on-demand, with limos whisking customers to their terminal as they arrive; however, when they return, they must request a pickup. From 06.00 in the morning to 23.00 at night, the airport metro station is operated in 20-minute intervals, with optimal times between 05.00 and 06.00 and on consumption (with an inherent response delay at other times). The total cost of NMC Nagpur's staff services was approximated and applied to the estimated driver split shifts for each service category (Table 5).

Table 5. Time comparisons between shuttle bus service and personal rapid transit (PRT) system

		Shuttle Bus time in minutes			PRT System time in minutes			Difference		
Metro station	***Passenger /day***	***Walk***	***Wait***	***Vehicle***	***Walk***	***Wait***	***Vehicle***	***Walk***	***Wait***	***Vehicles***
Bus stop	3590	1	15-20	8	0.6	0.2	2.5	0.4	19.8	5.5
Staff	532	1	15-20	8	0.6	0.2	2.5	0.4	19.8	5.5

Capacity

The minimum headway among both trains is calculated in railroad practice by the situation that if one train stops rapidly, the train behind it may also stop before a crash happens. A "concrete block stop" is an example of this. The minimum headway is frequently estimated to be at least two of these stopping distances in order to provide a margin of safety. The flow into and out of stations defines the headway since trains halt in line, each blocking the train in front, and the trains are long (Table 6) [3].

Table 6. Personal rapid transit (PRT) capacity performance comparison [3]

Mode	Heavy Rail	Light Rail	Busway	PRT	Average Difference
Headway (seconds)	110-200	70-360	20-300	0.6-3	283
Vehicle capacity	350-3000	250-360	30-70	3-6	257
Theoretical line capacity	6-90	2-30	0.5-16	3.6-28	17
Peak load factor	0.4-0.8	0.5-0.7	0.3-0.6	0.2-0.5	0.2
Observed	6-50	1-10	1-11	1-9	14

Revenue

Transportation revenue is the name given to the funds set aside for transportation. Taxes and fees that the government collects from transportation-related and unrelated activities and allots to finance transportation programmers are referred to as transportation revenue. The data were collected from NMC transport department. The parameters of data collected are numbers of passengers, total kilometers, total trips, revenue, earning per kilometers (EPKM). The difference is calculated between bus service and PRT system (Table 7).

Table 7. Revenue collection of shuttle bus service and personal rapid transit (PRT) system

Date	Total Passengers	Total Trips	Total kilometers (KMs)	Shuttle Bus Service		PRT System		Difference
				Revenue	*EPKM*	*Revenue*	*EPKM*	
10/11/2021	91	44	88	1123	12.76	910	10.34	2.42
10/12/2021	131	38	76	1593	20.96	1310	17.24	3.72
10/13/2021	125	40	80	1613	20.16	1250	15.63	4.54
10/14/2021	143	40	80	1783	22.29	1430	17.88	4.41
10/15/2021	58	38	76	692	9.11	580	7.63	1.47
10/16/2021	145	40	80	1830	22.88	1450	18.13	4.75
10/17/2021	98	42	84	1202	14.31	980	11.67	2.64
11/06/2021	54	38	76	477	6.28	540	7.11	0.83
11/07/2021	99	38	76	1008	13.26	990	13.03	0.24
11/08/2021	106	40	80	1061	13.26	1060	13.25	0.01
11/22/2021	142	44	88	1453	16.51	1420	16.14	0.38
11/23/2021	75	38	76	747	9.83	750	9.87	0.04
11/24/2021	91	40	80	901	11.26	910	11.38	0.11
11/25/2021	100	40	80	1021	12.76	1000	12.50	0.26
11/26/2021	69	38	76	692	9.11	690	9.08	0.03
11/27/2021	89	40	80	877	10.96	890	11.13	0.16
11/28/2021	92	42	84	909	10.82	920	10.95	0.13
12/13/2021	49	31	62	463	14.94	490	7.90	7.03
12/14/2021	69	31	62	698	22.52	690	11.13	11.39
12/15/2021	60	31	62	580	18.71	600	9.68	9.03
12/16/2021	30	31	62	300	9.68	300	4.84	4.84
12/17/2021	68	31	62	674	21.74	680	10.97	10.77
12/18/2021	57	31	62	503	16.23	570	9.19	7.03
12/19/2021	99	31	62	984	31.74	990	15.97	15.77
Grand total	2140	897	1794	23184	12.923077	21400	11.92865	0.9944259

EPKM, earning per kilometer.

RESULTS AND DISCUSSION

Feasibility

Operational Feasibility

The Figure 6 indicates that PRT system is more feasible than the existing bus service. The headway of the existing service is 5 minutes whereas the headway of the PRT system is 0.03 minutes. The speed of the existing bus service is more than that of the PRT system but bus departs according to their time and number of passengers. Therefore, PRT system is more feasible than bus system and should increase more use of public transportation [6, 7].

Safety

Safety is one of the most important parameters in public transportation. According to data analysis, the PRT system does not have any accident records till date whereas existing service reported number of accidents in Nagpur from 2015 to 2021. In 2015, 5 accidents resulting in one person's death and eight persons injured. In 2016, 6 accidents occurred with 2 persons dead and 7 persons injured. In 2017, 4 accidents occurred with one person dead and 5 persons injured [8]. In 2018, 5 accidents occurred with one person dead and 6 persons injured. In 2019, 6 accidents occurred with 3 persons dead and 9 persons injured. In 2020, one accident occurred with 2 persons injured. Due to COVID-19 restrictions, the number of accidents decreased. In 2021, 4 accidents occurred with 2 persons dead and 6 persons injured. So, after analysis, the PRT system came out as thee safest transport system (Figure 7).

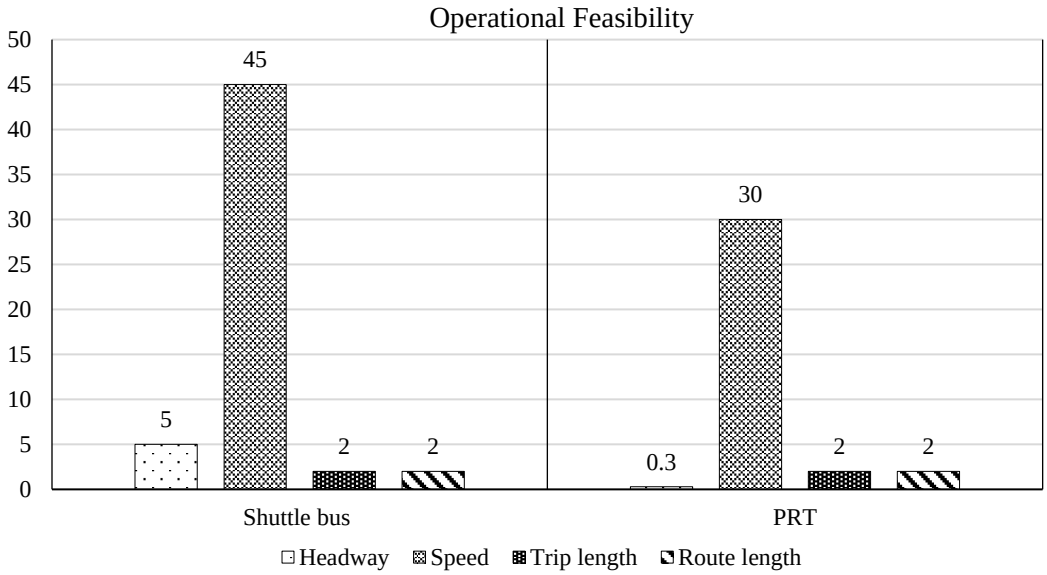

Figure 6. Comparative analysis between existing bus service and personal rapid transit (PRT) system.

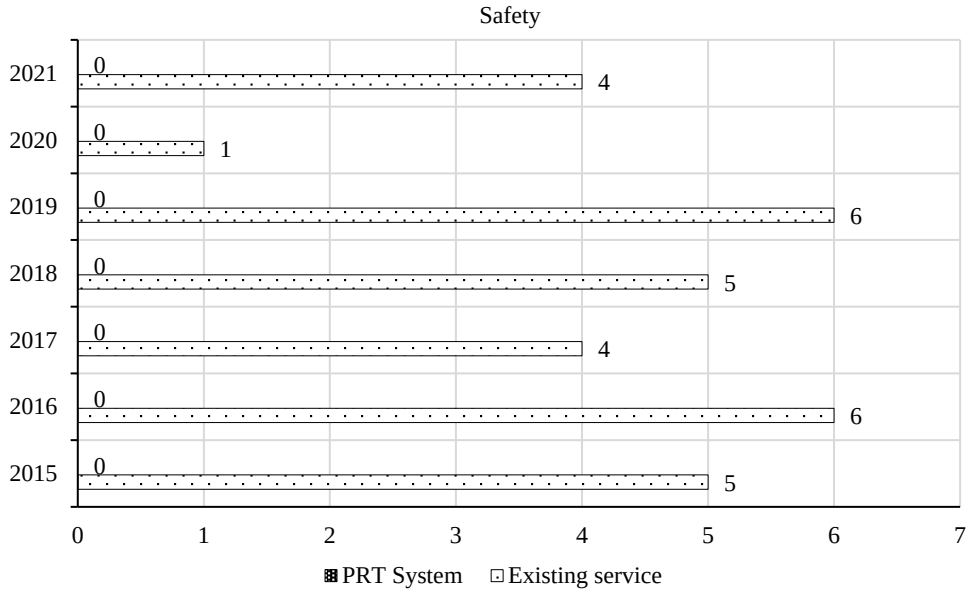

Figure 7. Comparative analysis of safety between existing service and personal rapid transit (PRT) system.

Level of Comfort

The PRT system is more comfortable according to passengers' survey and according to their rating. The passengers were not satisfied with the existing service for parameters like maintenance, air condition, air quality, and travel time. According to analysis, PRT system is more comfortable and feasible mode of transport (Figure 8).

Time Consumption

Time consumption is an important parameter in transportation. The passengers coming from metro need to walk 1 minute to bus stop and then wait for bus service for a minimum of 20 minutes and travel time is 8 minutes, whereas PRT system is more feasible because passengers need to walk only 30 seconds, waiting time is 20 seconds, and travel time is 2.5 minutes. The difference between bus system and PRT system in terms of walking time is 30 seconds, waiting time is 19.40 minutes, and travel time is 5.3 minutes. Therefore, PRT system is more feasible (Figure 9).

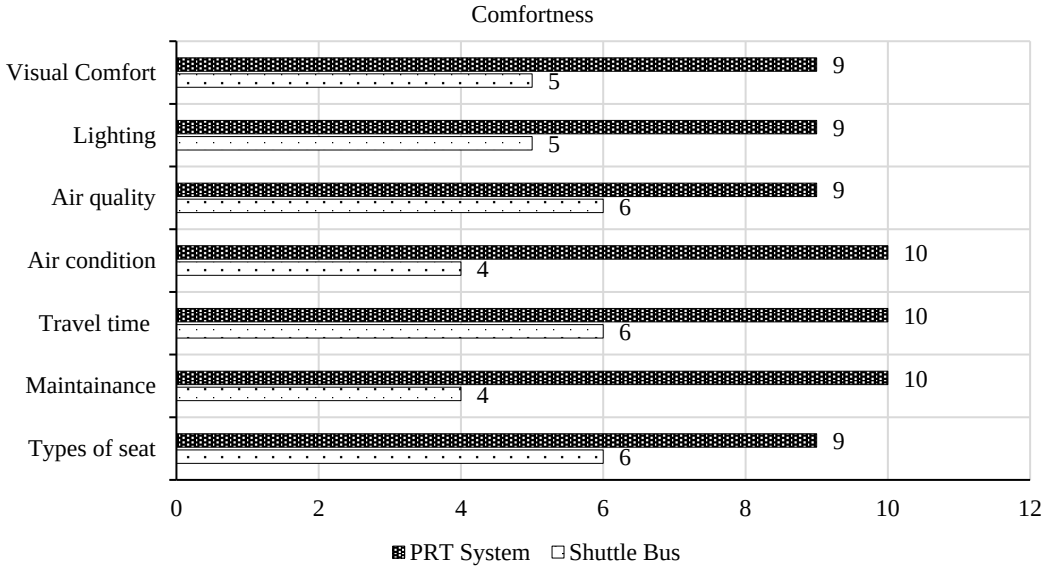

Figure 8. Comparative analysis of level of comfort between bus service and personal rapid transit (PRT) system.

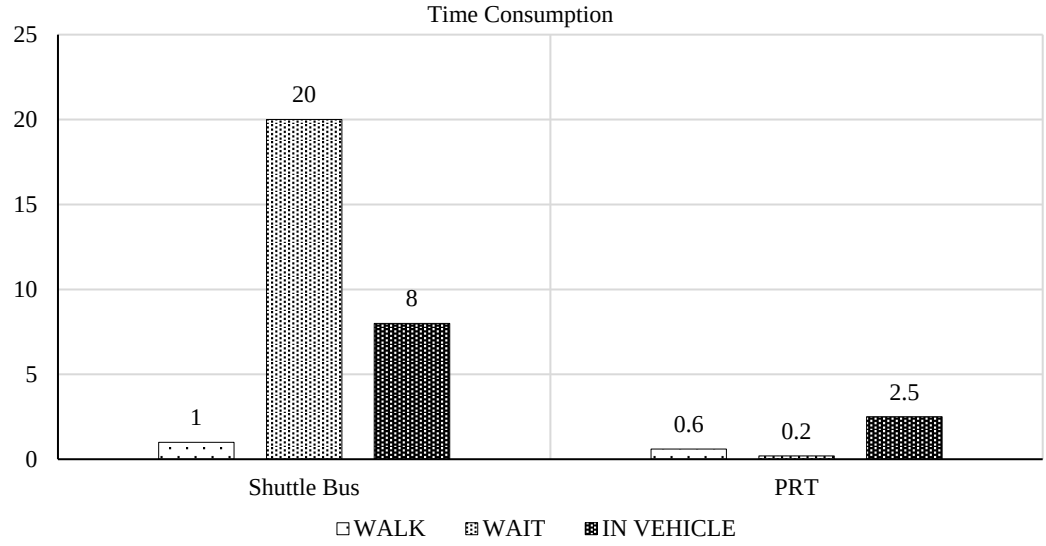

Figure 9. Comparative analysis of time consumption between bus service and personal rapid transit (PRT) system.

Revenue

Providing the appropriate service to the appropriate customer at the appropriate time and at the appropriate cost (price discrimination, market segmentation) is the goal of a transport system. Many economic sectors use it. Potential for cost savings and revenue growth. Automated fare collection technologies make this possible. The earning per kilometers (EPKM) of bus system is more than PRT system because there is no other option in Nagpur airside application service. The difference between both services in terms of EPKM is 3.83 INR from collected data (Figure 10).

Comparative Summary

Walking time: The inexpensive budget of PRT system allows for the introduction of additional stops without suffering significant costs overall. As a result, walking distances can be shortened considerably.

Waiting time: Studies for Heathrow ULTra use, utilizing a modelling device built in depth, reveal that with the 78 pods utilized in the cost profit estimations, average wait times are decreased to below 20 seconds. Trip time: PRT does not need to stop at two stations, it has a lower top speed but excellent trip times. Flexibility: PRT systems' compact size offers significant installation advantages. If necessary, the PRT system's radius of curvature can be as small as 5 m. PRT has significant advantages over automated people mover/light rail transit (APM/LRT) systems but cannot be as flexible as a bus. Disruption: Although some groundwork is unavoidable, the infrastructure may be erected in its entirety in a few months. For Heathrow, installation is anticipated to take place exclusively at night. Innovation: PRT's novel problems are frequently seen as a key deterrent when using PRT for airport applications, and they merit specific attention (Table 8).

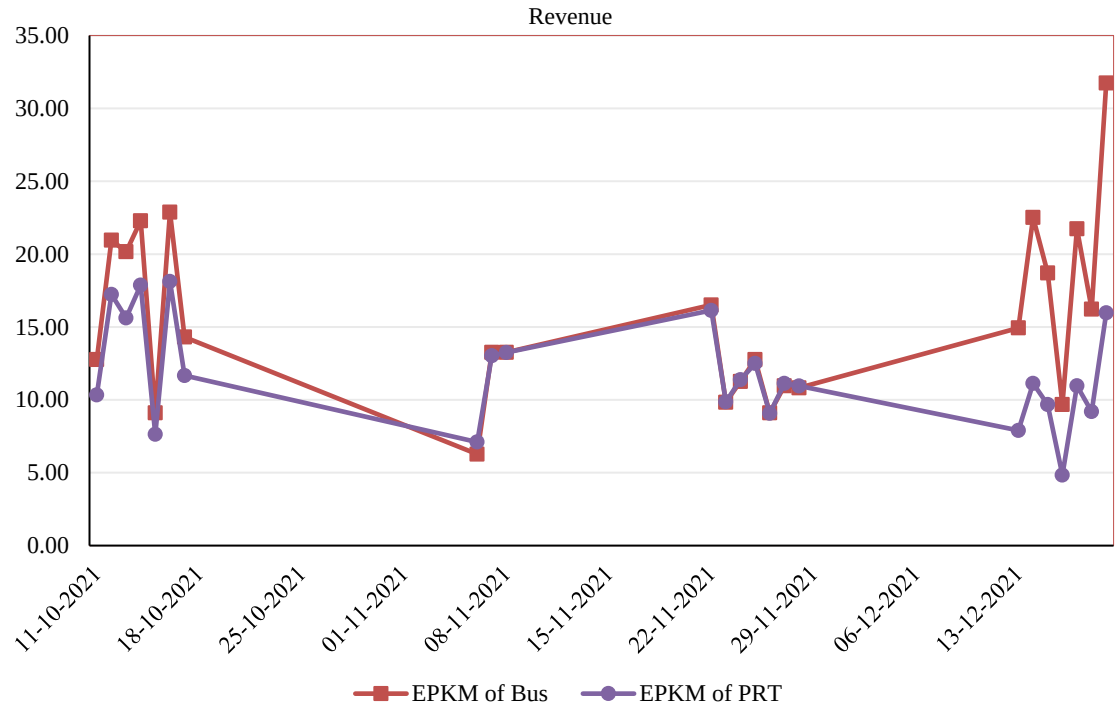

Figure 10. Comparative analysis of Revenue between bus service and personal rapid transit (PRT) system.

Table 8. Comparative summary of modes of transportation

	Automated People Mover	**Light Rail Transit**	**Bus**	**Personal Rapid Transit System**
Walking	Moderate	Moderate	Moderate	Good
Waiting	Bad	Bad	Bad	Good
Trips	Good	Good	Bad	Good
Flexibility	Bad	Bad	Good	Moderate
Disruption	Bad	Bad	Good	Good
Cost	Bad	Bad	Good	Moderate
Invention	Moderate	Moderate	Good	Moderate

Thermoplastic and Thermosets

There are countless types of thermoplastics and thermosets, each with different material properties like plastic strain rate and service temperature; however, these variations are typical rather than universal. Designers must consider the benefits and drawbacks of each class of polymer, as well as categories, applications, and examples of frequently used materials, in addition to knowing whether a polymer is thermoplastic or thermoset (Table 9).

Table 9. Comparison between thermosets and thermoplastics

Type of Resistance	Thermosets	Thermoplastic
Heat	More	Less
Chemical	More	Less
Deformation	More	Less
Impact	Less	More
Shattering	Less	More

CONCLUSION

When connecting the staff and passenger parking lots to the airport terminal areas, PRT system can provide several advantages. PRT provides:

- The speed, convenience, and privacy of a private vehicle; the capacity of public transit; fewer or no waits and more frequent stoppages; a classification that is peaceful and non-polluting.
- A small-scale, unobtrusive guideway that can accommodate sharp turns, narrow radii, and steep grades; a system that is modular and adaptable for quick, low-cost construction that causes little disturbance and can be moved about reasonably simply; infrastructure that is successfully incorporated into the airport in an engaging and enjoyable manner, with stations located inside passenger terminals.

PRT is thought to be in a good fit for airports' demands for landside transportation:

- It provides a 40% operational cost savings over the current transport bus services.
- The predicted average passenger time savings at Heathrow is 8.5 minutes, or 60% of the existing transfer times.
- The system is expected to have affordable capital costs, especially when compared to APM/LRT, and it offers a 22% first-year rate of return, primarily in the form of passenger advantages. There are risks with any new system, however, and these costs are expected to be moderate. These are allegedly controllable for ULTra.

Thermoplastic sandwich body panel:

- For a mass transit vehicle, a thermoplastic sandwich body panel's design, analysis, and production were completed.
- The face sheet was made of PP honeycomb, and the core was made of glass/PP woven tape. The design and analysis were done using the Pro/E, Hypermesh, and codes.
- A body panel pan component segment with a PP honeycomb core, an inner face sheet made of two layers of woven tape glass/PP, and an outer face sheet made of four layers of woven tape glass/PP was successfully produced.
- The pan portion of the body panel underwent flexural testing, and the American Public Transportation Association (APTA) static design requirement was effectively met. The measured deflection is only slightly less than what the finite element analysis predicted.
- The localized deboning and the relative motion at the adhesively bonded contact are reasons for the discrepancy in deflection between the finite element prediction and the experiment.
- In the long term, the system might provide comparable advantages for airside operations.

REFERENCES

1. Ultra Global PRT. Heathrow announces plans for an additional Personal Rapid Transit (PRT) system. [Online]. February 13, 2013. Available at https://www.ultraglobalprt.com/heathrow-announces-plans-additional-personal-rapid-transit-prt-system-heathrow/
2. Ning H, Janowski GM, Vaidya UK, Husman G. Thermoplastic sandwich structure design and manufacturing for the body panel of mass transit vehicle. Composite Struct. 2007; 80 (1): 82–91.
3. Anderson JE. An Intelligent Transportation Network System: Rationale, Attributes, Status, Economics, Benefits, and Courses of Study for Engineers and Planners. Minneapolis, MN: PRT International LLC; 2009.

4. Yadav DK, Ghodmare SD, Kumar NN. Mitigation of blackspots on highways by the application of safe system approach. Mater Today Proc. 2022; 52 (Part 3): 1228–1235.
5. Ghodmare SD, Gulghane A. An attempt for sustainability evaluation considering implementation of rapid transit system. Mater Today Proc. 2022; 60 (Part 1): 405–413.
6. Ghodmare SD. Transportation planning using conventional four stage modeling. Turk J Computer Math Educ. 2021; 12 (12): 2891–2897.
7. Ghodmare SD, Khode BV, Bajaj P. Application of the multi attribute utility technique with its for sustainability evaluation of emerging metropolitan city of Nagpur. Int J Civil Eng Technol. 2019; 10: 942–950.
8. Gupta MP, Ghodmare SD, Khode BV. Feasibility study on widening of roads as per traffic survey. Des Eng. 2021; 2021 (4): 210–217.
9. Pandey A, Gulghane A, Shah V, Khode B. Assessment of on-street parking issues in CBD areas – a review. Int Res J Eng Technol. 2020; 7 (5): 1491–1495.
10. Global Ultra PRT. World's first and largest urban PRT system announced. [Online]. December 14, 2011. Available at https://www.ultraglobalprt.com/worlds-largest-urban-prt-system-announced/

