Personal Rapid Transit – Selected Problems

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Abstract: The paper deals with a new municipal transport system referred to as PRT (Personal Rapid Transit). Shown in the work is a specification of this type of transport and essential problems encountered in the implementation phase in the aspects of design, control, dynamice and ergonomics.

Key-Words: - Personal Rapid Transit, Computer simulation, Dynamics, Ergonomics

1 Introduction

Commonly known are the problems met in service of the contemporary urban agglomeration public transport systems. Some of the most essential are:

- susceptibility to clash,
- dense traffic intensifying tendency to jams with low traffic capacity resulting especially in rush hours,
- high energy demand,
- considerable environment pollution,
- high land area requirement for installation of infrastructure systems,
- ever growing costs of urban infrastructure systems.

New solutions related to different concepts of control, modifications and improvements to the existing public transport systems are persistently reported. Particular attention should be paid to research of issues of the new urban transport means and systems. No doubt, a good example of such is the concept of PRT system. The description covers a transport system which is able to combine positive features of the individual and mass transport systems usually described as the "point to point" or door to door" transport type using small size (four passengers) vehicles remotely controlled to move suspended under a lightweight trestle structure – most often an overhead rail. PRT is classified as AGT („Automated Guidway Transit") consisting of:

- Shuttle-Loop Transit,
- Group Rapid Transit
- Personal Rapid Transit
- Hybrid PRT/GRT Service

(This classification has been suggested in one of rather scarce item of the PRT, viz: Fundamentals of Personal Rapid Transit, by Jack Iring et al. Lexington Books 1978).

The Authors are convinced that some conditions exist to believe the RPT systems would win and soon be implemented in urban agglomerations first playing the role of a secondary transport system, which within some two or three decades might take the part of the dominating public transportation method. It is a solution to meet the needs not only big urban agglomerations such as Warszawa or Wrocław but it might provide a good support for smaller spa towns like Zakopane or Krynica, providing for public communication service but also performing as a specific town attraction (similar to Sydney monorail or Grenoble mountain cable railway). The most essential features of the systems are:

1 Collision free traffic with high safety of the vehicle movements and functional reliability expected,

2 High carrying capacity of the PRT system when reasonably developed in comparison to uderground railway system,

3 Very low energy demand (also resulting from the fleet flexibility – only the "occupied" vehicles are on the move),

4 Minimum impact on environment (PRT is a „zero pollution" or „emission free" communication service),

5 Minimum land area required for development of the infrastructure and low construction costs in comparison with the other municipal transportation systems (as for example those using rail tracks),

6 High public acceptability (as revealed in open inquiries carried out for the British ULTRA system),

7 Widely applied computer techniques and state of art navigation systems for effective control functions and optimum travel routes.

8 Easy adaptability to the handicapped passenger requirements.

Donn Fichter, the US urban transport service planner was the first to present in 1953 somehow fantastic image of the urban transport system of the turn of twentieth century. In 1964 he published a book "Individual Automated Urban Transport System". A report in which the PRT systems were indicated for consideration as the public transport systems in urban agglomerations was published by the Department of Housing and Urban Development in 1966. In Europe, first research work started in France with Project ARAMIS, intended for implementation of the pilot line in Paris in 1967. Unfortunately, the Project failed. Similar Projects were undertaken in Japan in the years 1970-78. This time the Project has been abandoned on the excuse that this type of transport should be considered as a particularly dangerous concept. Seventies were not exceptionally favorable for the PRT development work. Efforts were made by UMTA in the USA to implement American PRT system in 1973. However, these were also not a success. Similar attempts made in Germany did not meet the expectations (CABINENTAXI Project). The reasons for this train of failures is, according to Prof. J. Edward Anderson, one of the most determined advocates for this system, and unqustionable engineering authority on the PRT problems, resulting from the following [1,2]:

1. inadequate development of the computer, telematics and electronics sciences /the most complex problems met in the PRT research work are those related to control and navigation; while only the state of art computer and navigation systems provide for adequate tools to build PRT systems/
2. inavailable legal issues related to such system,
3. lack of common awareness of the environment protection problems,
4. relatively recently manifesting strict limits to further development of the existing systems,
5. relatively recently manifesting problems of terrorism threat (due to specific considerable diffusion of the transport means and easy/inexpensive monitoring ways, PRT systems are naturally resistant to the acts of terrorism),
6. lack of standards (this is the most symptomatic reason retarding implementation of the new issues),
7. PRT specific features, which might enhance monopolistic practices in building and service of the system.

Overall development of engineering science and fundamental problems arising in front of urban transport systems by the turn of twentieth century and at the start of twenty first century resulted in the attention once again paid to PRT. The new solutions have suddenly burst upon out of nothing. For example Rayteon, SkyTran, Cyber Cabs. Almost completed in Europe is Project ULTRA, first expected to be put in service in Heathrow airport (planned for 2008). Equally advanced is the Project of the Korean/Swedish consortium VECTUS Ltd. planned to be implemented in Upsala in 2009. Also, the work has been commenced on the already mentioned US SkyWeb/Taxi 2000 system. Frst in Poland suggesting application of this system was O. Mikosza. His concept, Mister is based on introduction of the specific static rail switching system and on using the overhead suspension rail. Research work on the PRT system has been commenced in Warsaw University of Technology [3].

2. PRT System, Polish Concept, General Approach

When starting research work at the Faculty of Transport the following requirements were assumed:

1.four passenger, electrically driven vehicles moving under an overhead rail (to meet the requirement for lightweight infrastructure in door to door communication) should be used for the PRT system,

2. critical for PRT systems are switches to provide for changing travel direction. Switches should be static, without any movable components. To change travel direction special mechanism would be installed on the vehicle.

3. the PRT line network is planned in two layers (see Fig. 1) with Layer One (consisting of the main trunk lines with the vehicles travelling at constant speed V (approximately 50 kmphr) with 10 m separation, and Layer Two (covering the secondary lines on which the vehicles develop speeds from 0 to 50 kmphr and are specific for the door to door transportation idea, which means picking up passengers at place where they stay at the start of the journey and leaving them at the destination point),

4. borne in mind should be that when shifting from Layer One to Layer Two the vehicles must not retard traffic on the trunk line and must not produce such effets on passengers which are inadmissible for the human organisms in the aspects of unbalanced accelerations or rapid speed changes in the form of jerks; consequently, transient curving lines should be applied,

5. it is required, that overall dimensions of the PRT vehicles should comply with the applicable ergonomical requirements and must make it possible to carry wheel chairs for the handicapped passengers (the seats should, if necessary, be made foldable to accept the wheel chair and the attending person),

6. it is also desirable, that the system should be planned so as to perform at least equal or even higher capacity than those presented by the other public transportation systems which might be currently used in service. The scope of research on the PRT communication system covers a number of problems, which include: dynamics,

control methods, safety, reliability, ergonomics, engineering design etc. This paper deals with two aspects only which are limited to structure selected dynamice problems.

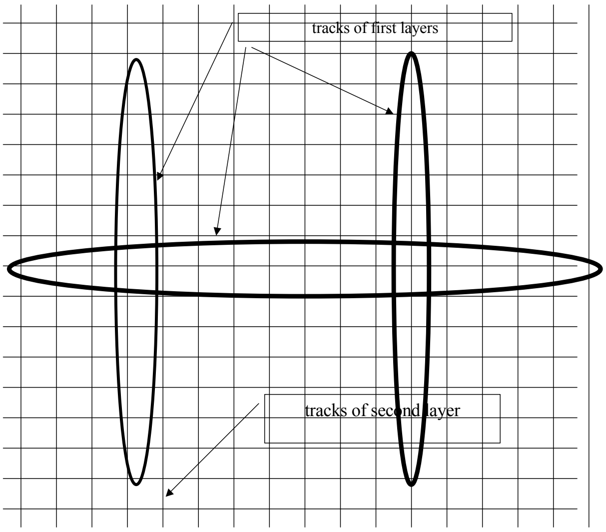


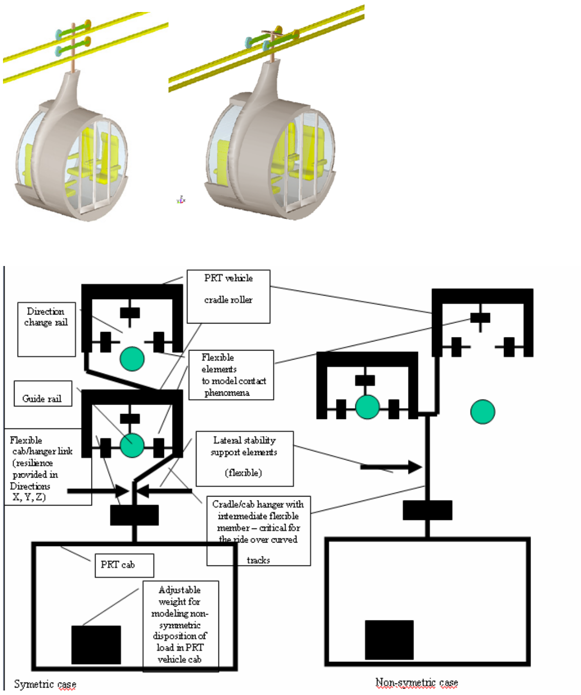
Fig.1 PRT system communication line network concept

3. SELECTED PROBLEMS ON VEHICLE PHYSICAL STRUCTURE

Physical structure of the PRT system consists of: running system, rail track, power supply system, travel direction change (switching) system, passenger cab, emergency features providing for passenger escape (leaving this time the safety features built into PRT vehicle control and navigation systems). The paper concentrates rather on switching mechanism. It is recommended in majority of the PRT related literature, that switching operation should not be performed by compulsorily movable rail track elements, but should be attached to the vehicle structure. This system is rather oddly referred to as a "static switch". There are several reasons to support such an issue:

- it is required that the communication line infrastructure should be easy to extend [2],
- considering the distance required to separate individual vehicles and specific traffic control conditions it should be more practicable to have the travel direction switching mechanism on the vehicle [1],[2].

One of the primary „static switch" concepts intended for use in PRT vehicles moving under the overhead rail track has been patented by O. Mikosza. [3]. This primary structure has been modified and again patented by J. Madej and W. Choromański [3]. See Fig. 2 for comparison of the two issues. In both cases travel direction switching operation consists in rising or lowering the rollers riding on the rail. In the solution presented by O. Mikosza there are two rails disposed in horizontal plane resulting in specifically non-symmetric travel movement on straight-on sections of the track (resulting in high pressure on the stabilizing support). In the J.Madej/W.Choromanski solution the rails are disposed in vertical plane. In this case the symmetric system is demonstrated with very low reaction forces acting on the stabilizing support. Attention should be paid to resilient joint between the cab and the driver system (Fig. 2). This is of particular importance for the ride on a radius section of the track. The vehicle will in natural way tilt aside and reduce lateral accelerations acting on passengers bodies. Both solutions have been tested under simulated ride conditions in ADAMS software environment. Consideration was given to the cab movement over straight on – transient curve – radius bend – straight on line. Review of the movement included acceleration phase up to a speed of 50 kmphr and then, leaving the Layer One trunk line and passing to Layer Two line with speed reduced down to 30 kmphr. Bend parameters were selected so that the unbalanced lateral accelerations would not exceed 0.26 g. For exemplary results see Fig. 3. The movements were reviewed within the system of coordinates moving along the track line at the above indicated velocity values. Axis X indicates direction of the cab movement, but axis Y indicates the direction lateral to that. Both solutions yield similar results. The effect of the resilient joint (applied for coupling driver system to the cab, see Fig. 3.2) on reduction of the accelerations can be noted.



a) b)

Fig.2 a) PRT vehicle primary structure - symmetric b) PRT vehicle structure - non-symmetric

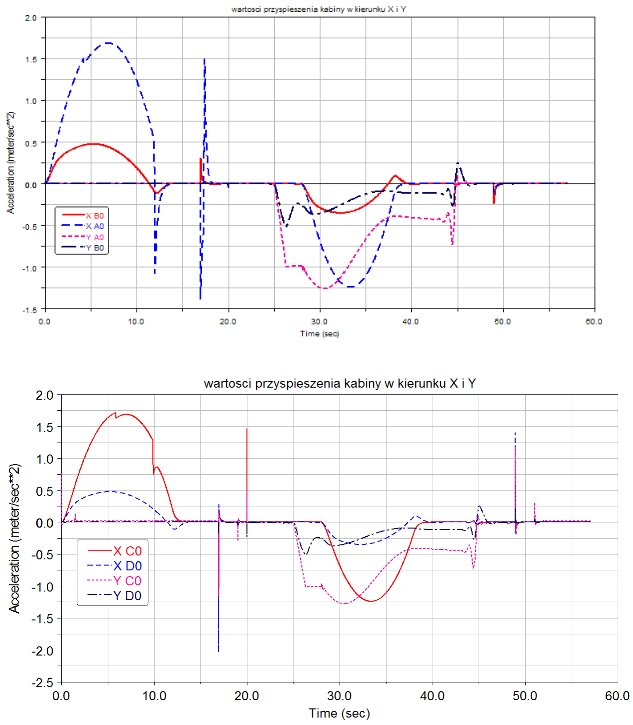


Fig.3. Impact of accelerations on passenger. Symbols: · A – symmetric model without cab shock absorbing facilities,· B – symmetric model with shock absorbing facilities provided,· C – non-symmetric model without cab shock absorbing facilities,· D – non-symmetric model with shock absorbing facilities provided,

4. SELECTED PROBLEMS ON PRT VEHICLE ERGONOMICS

It was a prerequisite for the PRT vehicle design work that it should depart from the aspects of commonly used and typical public transport means and resembling mountain cable railway cars. Suggested design features are sufficiently specific to be readily recognizable in future and immediately identified with this particular urban transport vehicle. Of considerable importance was, that the vehicle features should emphasize modern and specific character of this transport type, but, at the same time were in harmony with urban landscape. It was agreed upon, that the vehicle shape should be based on ellipse, which provided for distinct line. Due to specific role of this transport it has been considered as an important question what proportions of the opaque to transparent body panels should be applied, to produce PRT vehicle with user friendly and safety promising features.

Multiplicity of factors had been considered before final dimensions of the vehicle were identified. Fundamental of all considerations is, that this should be an individual transportation system. Thus, it has been designed for use by four passengers, or by a wheel chaired handicapped person with one attending person at the maximum.

Another important problem to solve was how to provide for adequate safety of the passengers getting in or getting out or pushing a wheel chair in or out (when the vehicle leaves the trunk line and would approach the platform). In this situation the difference in height between vehicle floor and platform, or too wide gap between vehicle floor and platform might create serious problems. A solution to these was found in the form of an automatically extended vehicle threshold plate as wide as the door and as deep as to cover the gap and serve as a ramp which would make it possible for pushing a wheel chair in or out from the vehicle by handicapped or mothers pushing their babies in prams. To sum up – internal dimensions of the vehicle should provide for comfortable travel of 90% of Polish population, which means persons who, in the antropometric aspect, remain between the 5 and 95 centile (C5 and C95). Considered in the requirements were both physically fit and the wheel chaired handicapped persons.

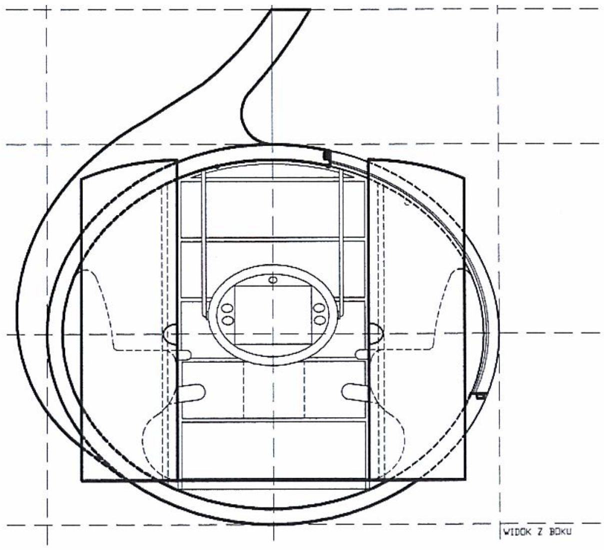


Fig.4 PRT vehicle side elevation (on the door side)

In addition to the requirements on the vehicle shape and its overall and internal dimensions the following problems have been reviewed in the design work:

- vehicle outfit and its layout,
- internal material environment within the vehicle (noise, lighting, colors, vibrations),
- passenger interface in the remotely controlled vehicle (control monitor design and functions),
- travel route planning and performance procedure.

5. CONCLUSIONS

The review and research works indicate, that PRT system is potentially interesting solution which might compete with the existing public transport systems. To the Author's suggestion PRT system can be considered as any of the following function:

1. a global public transport solution in big urban agglomerations (such as Warsaw) referred to as High-Capacity Personal Rapid Transit,
2. a local public transport solution in big urban agglomerations (such as transport service to the biggest in Europe passenger changing center: Warszawa-Centralna railway station),
3. a transport solution to specific transportation needs (in big shopping centers, or in Warsaw Technology Park),
4. a transport solution in the towns of specific character (such as Zakopane, Szczyrk),
5. attractive sight seeing feature and the town specific installation (such as a communication between Vistula River Bank and the ZOO garden)

However, the system implementation phase requires intensive research and planning work of interdisciplinary nature to be completed before. So far it is not practicable yet to indicate which PRT form should be considered as the optimum solution for particular problems met in particular circumstances and conditions.

References:

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