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Development of Scaled PRT System Based on In-track Linear Induction Motor

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Abstract: This paper introduces a scaled PRT system, by which the expense and time for development can be reduced and the field applicability can also be improved. Furthermore, due to the propulsion based on the in-track linear induction motor (LIM), the need to carry motors and controllers on each vehicle and to provide guideway power rails can be eliminated, and thus the economical efficiency can be improved for larger systems with a large number of vehicles.

1. INTRODUCTION

Congestion in road transportation and Kyoto protocol for restricting CHG emission have encouraged to develop innovative transit systems. Furthermore, due to the high operation cost in mass transit system and limited service from line-haul system, there is a growing interest in the use of PRT systems for a variety of public transport applications, at airports, new towns, new business districts, sports complexes and other special situations, see Anderson (1996), Szillat (2001), Dunning (2003), Carnegie (2007).

As a fully automated urban transit system, PRT systems offer a rapid and personalized door-to-door transport service on demand. Because PRT stations are offline, all travel is non-stop between origin and destination and therefore, overall trip time by PRT is short and a proportionately greater number of stations are practical.

Due to aforementioned benefits in transport effectiveness from the point of view of the passenger and the potential to provide a cost effective alternative to cars for many urban trips, various element techniques realizing the functions of PRT are developed rapidly and commercialized in many fields. It is within bounds to say that the high-reliability and stable interfaces between each element technique, control of PRT, and the reliability of the algorithm realizing operation characteristics of PRT are everything to the development of the PRT system.

Most developers of the traffic systems utilize test track and simulator to validate the interfaces of the system and the algorithms. However, the validation may be restricted due to the limitation of the test track and simulator.

The test track aims to commercialize and certify RAMS (Reliability, Availability, Maintainability, Safety) and thus has simple network generally. Therefore, there is a limit to validate the operation algorithms (empty vehicle control, routing etc.) and operation performance (average speed, transportation capacity, average waiting time etc.), although it is possible to validate the basic control algorithms (propulsion control, position control, headway control, switch merge control etc.) and interfaces etc. The operation related matters can be tested by enlarging the network, but which may result in too much additional expense burden.

On the other hand, the simulator provides various networks and conditions to test and predict the results. However, a series of processes such as collecting and processing information, controlling and operating the vehicles is replaced using the predicted data other than the data collected in the real fields, which may result in the big error between the provided data and the data collected in the fields. Therefore, the microscopic control algorithms validated by the simulator that is based on the predicted data are not sufficient to deal with various stations in the real fields.

In this paper, a scaled PRT system that integrated the advantages of the test track with that of the simulator is introduced, by which the developed microscopic vehicle control algorithms can be tested and improved with the macroscopic operation algorithms so that the field applicability of PRT can be improved ultimately.

2. ARCHITECTURE & CHARACTERISTICS OF SCALED PRT SYSTEM

Scaled PRT system, a one-tenth scaled model of test PRT system, is consists of station, vehicle, depot, guideway, and each component is operated systematically by the control system as shown in Figure 1. In another viewpoint, the scaled PRT system can also be divided into four systems such as control, propulsion, vehicle&guideway and communication system. This paper mainly introduce control and propulsion systems.

Control & Propulsion System Existing autonomous public traffic system, such as LRT (Light Rail Transit) or monorail etc., adopted on-board motor propulsion and synchronous centralized control method, which is widely used in line-haul system that is operated at regular time intervals. In the case of this control method, track circuit is required to connect the vehicle controllers with the controllers on the ground, and additional power supply equipment is also needed to supply the power from vehicle itself for the propulsion and other functions. However, the

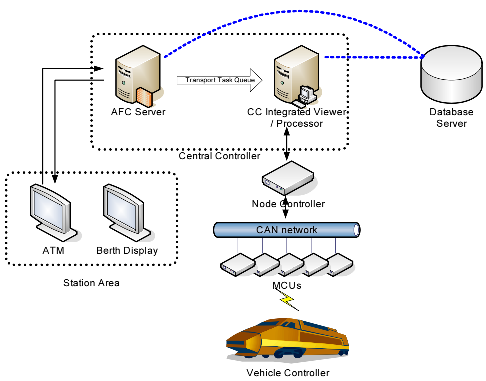

Fig. 1. Architecture of Scaled PRT System

power supply system may make the system bigger and result in the increase of additional expense. In addition, the power supply equipment may injure the beauty of the vehicle exterior because it should be installed outside of the vehicle. To cope with such drawbacks and improve the system reliability and safety, make the system be lighter and strengthen the price competitiveness, a unique design, i.e., in-track propulsion based on LIM and asynchronous distributed control method is adopted. This control method can be considered as the most economical and reasonable method to provide the non-stop trip for the passenger's discrete request as required in PRT criteria.

The architecture of the asynchronous distributed control system consists of central, node, motor and vehicle controllers with wired/wireless communication system as interface. The controllers receive input from a variety of wayside and vehicle sensors that measure characteristics such as position, speed, temperature, etc., and generate information for the PRT drive and operation, monitoring through the hierarchical duty assignment. All control functions as well as the propulsion and braking commands are executed by motor controllers. It should be noted that there are virtual tracks except the physical tracks as a characteristic of the scaled PRT system. Therefore, it results in virtual node controllers.

As aforementioned, one of the characteristics of this scaled PRT system is the in-track LIM based propulsion. On account of the simplicity, reliable design and high work capacity, LIM is considered to be an optimal propulsion solution for the PRT system. The motors are positioned on the guideway and the reaction plate is attached to the bottom of vehicles. This design requires motors to be spaced for every length of the vehicle reaction plate to provide continuous propulsion and braking at any point along the guideway. Permanent magnetic brakes and double LIMs reinforce braking and accelerating thrust to meet the constraints on station length as well as mainline speed. The primary LIM design to provide propulsion and braking along the main guideway and an alternate LIM to provide higher propulsion and braking levels in acceleration and deceleration guideway sections. Permanent magnets mounted in the guideway supplement LIM braking in deceleration sections.

It can be noted evidently propulsion using in-track LIM eliminates the need to carry motors and controllers on each vehicle and to provide guideway power rails. This design simplifies each vehicle and may be proved to be beneficial for larger systems with a large number of vehicles. Furthermore, the LIM design provides predictable braking levels independent of the weather and roadway coefficient of friction so that the propulsion can work invulnerably even in harsh weather condition.

Vechicle & Guideway System The vehicles, composed of bogie and cabin, feature a modern, stylish and aerodynamic design and glass sections in the doors and windows are expected to provide an excellent view. As the case of the virtual tracks, there are ten virtual vehicles except five physical vehicles in this scaled PRT system, and the number of the virtual vehicles can be increased to the maximum capacity if needed as in the case of simulator, which is difficult in the test track systems. In addition, the circular tube is selected as the main guideway beam structure, where the interior of the tube is used as a conduit for electrical, communication and other cables that are required to support the system. The guideway is made of ultra-light steel structure that only requires few pillars and short construction times that will make minimal impact on the environment. The standardized design of the system is intended to facilitate the installation and extension of the existing track system.

Communication System The function of the communication system is to transmit critical control commands and status signals between controllers, vehicles and motors. This make it possible to automatically control and monitor the behavior and position of vehicles and the status of motors. Passengers inside the vehicle should also be able to control the route of their vehicle.

Besides aforementioned systems, there is an automatic fare collection system with ATM (Automatic Ticketing Machine) and BD (Berth Display) as its subsystem. ATM receives the travel information from the passengers and provides vehicle information. BD is installed on the front of berth and shows the information of the berth where the vehicles assigned to the passengers will be stopped.

3. CONCLUSION

This paper introduced a scaled PRT system that integrated the concept of the simulator and test track so that the expense and time for the development can be reduced and the field applicability can be expected to be improved. Furthermore, due to the use of propulsion system based on in-track LIM, the economical efficiency can also be improved especially for a larger system with a large number of vehicles.

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