FINAL REPORT

VERIFICATION TESTING OF THE TRANSETTE PERSONAL RAPID TRANSIT SYSTEM

EES/GIT Project B-432

By

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I. INTRODUCTION

On 27 June 1974, the Engineering Experiment Station (EES) at the Georgia Institute of Technology received Grant No. RDI-74-22600 from the National Science Foundation (NSF) to manage a program involving installation and verification testing of a prototype personal rapid transit (PRT) system. The system was designed by Transette, Inc., an Atlanta-based firm, which supplied the equipment and performed the installation under subcontract from Georgia Tech. Through an inter-agency agreement with NSF, the Transportation Systems Center (TSC) of the U.S. Department of Transportation (DOT), was originally expected to conduct a test program to evaluate design characteristics and safety aspects of the present Transette System.

The Transette System for personal transit service is intended to fulfill the need for a system that can furnish effective, low-cost transportation of people over moderate distances in high pedestrian traffic areas. It operates on a novel drive principle and appears to have significant advantages of safety, operating efficiency, and economy compared to other techniques of personal rapid transit previously proposed.

The experimental system, which has 3000 lane feet of track, is located along a route of high pedestrian traffic between the Georgia Tech Student Center and a point across the street from an area of student dormitories. Installation is complete with the exception of a few problems for which solutions have been designed but have not been implemented due to lack of funds. Although these problems hinder the continuous operation of the system, the basic technology has been demonstrated and there appear to be no major technical barriers to developing a fully operational prototype system.

II. BACKGROUND

When the Transette System was described and a scale model of the basic design concept demonstrated to Georgia Tech representatives, it was recognized that the system has great potential for use on campus as well as in other public areas to alleviate traffic congestion and parking shortages. The Georgia Tech technical staff members believed that the system had been developed to a point where credibility of performance would have a critical effect on its future economic development and marketing potential. It was also felt that verification testing by an impartial, scientifically recognized agency could establish that credibility and thereby influence favorably the potential implementation of the system. Georgia Tech was aware that the National Science Foundation program of Experimental Research and Development Incentives was designed to provide experimental evidence concerning various incentives which the Federal Government might use to increase the application and use of science and technology in the public sector by (1) identifying the institutional barriers to innovation, and (2) testing appropriate Federal action which might reduce such barriers. The objectives in suggesting installation of a prototype of the Transette System on campus were to establish the technical feasibility of the basic concept and to demonstrate its practicality in routine service. Toward these goals, Georgia Tech requested and subsequently received funding from the NSF Experimental R&D Incentives Program.

III. TECHNICAL DESCRIPTION OF THE SYSTEM

The description and illustrations in this report are intended to provide a general understanding of the system design; no attempt has been made to present full engineering details of the system.

The Transette System is a new concept for personal rapid transit which emphasizes low cost, passenger safety, high performance capability and dependability, very low energy consumption, and low air pollution and noise. The utilization of a unique drive system allows passive four-passenger cars to be driven along a two-way concrete track, eight feet wide, at speeds up to twice that of a narrow driving belt built into the track system. The cars have four wheels (one driving and three roadway) with pneumatic tires. The driving wheel is located at the rear of the car, and positioned out of alignment with the roadway wheels so that it engages the 5-inch-wide driving belt. The driving wheel is coupled through a 2:1 gear train to the rear roadway wheel, transmitting the belt velocity through the drive wheel to the roadway wheel and propelling the vehicle with a velocity twice that of the driving belt. (See Figure 1.)

A variable-speed transmission allows the vehicle to maintain continuous engagement with a driving belt. A multi-plate clutch allows acceleration and deceleration of 2 mph/sec along the belt from fully stopped to maximum speed condition.

Two-way traffic is made possible by the installation of a double guide rail down the center of the 1500 foot track. Two sets of guide wheels engage the guide rail. At each end of the track, the guide rails diverge and become tangent to a motor-driven carousel. The vehicle drive wheel passes from a deceleration belt (terminating at the carousel) onto the carousel and continues onto an acceleration belt at the opposite side of the carousel.

Belt drive motors are located in pits below the guide rail. Acceleration and deceleration belts operate only when needed. They serve one-way traffic and form individual loops by returning in a trough underneath the concrete slab. The remaining drive belts are designed for continuous operation. To reduce costs, each belt serves two-way traffic. This is accomplished by aligning the belt so that it travels in one direction along

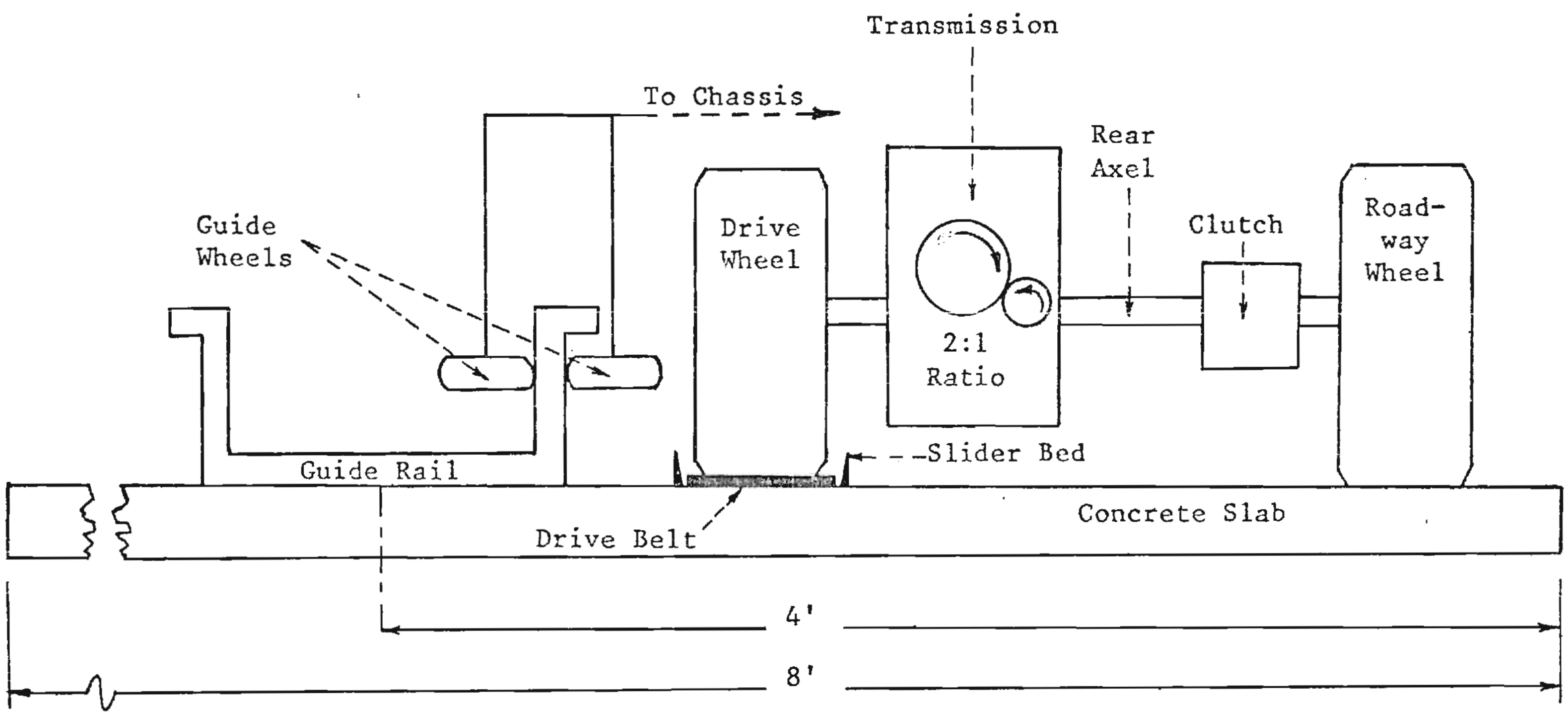

Figure 1. Cross-sectional diagram of Transette guideway and drive train.

the track. From the drive pulley, it continues until it drops into a pit and is guided by idler pulleys to make a 180° turn in the pit. It then continues up the opposite side of the track and into the drive pulley pit where it makes another 180° turn. (See Figure 2.) The distance from one belt to the next is approximately 3 inches.

Belts slide on a stainless steel slider bed with runs alongside the guide rail and is flush mounted to the concrete slab. The belt configuration is designed to accommodate various velocity requirements along the track and to maintain maximum vehicle speed for as much of the track as possible. The maximum belt speed is 7.5 miles per hour and the maximum vehicle speed is 15 miles per hour on the longest track section, which is 750 feet long.

The belts and carousels operate automatically according to signals from the control logic. Metal sensors located along the track detect passing cars. The logic is designed to maintain a minimum 15-second headway between cars, manage merging from the off-line test station, and stop and start cars automatically at the passenger stations.

For testing purposes, the present track configuration includes a 7.5% grade section, a 32° bend, and the off-line test station. A control house overlooks the entire layout.

For a car to stop at the off-line station, a button in the car must be pushed. This lowers a metal flag below the car which signals a metal detector, causing an impulse to be sent to the control logic. The impulse causes the setting of a switching mechanism located along the track. As the car passes over the set switch, the switch causes the main-line guide wheels to disengage and the off-line guide wheels to engage the off-line guide rail located along the outer edge of the concrete slab at the station. The main belt overlaps the ends of the deceleration and acceleration belts to and from the station so that the drive wheels are always in contact with some belt.

The car door is opened and closed by a cable attached to a wheel mounted perpendicular to the chassis. As the vehicle passes over a metal strip mounted to the concrete slab, the wheel is rotated by friction produced between it and the belting material mounted on the metal strip.

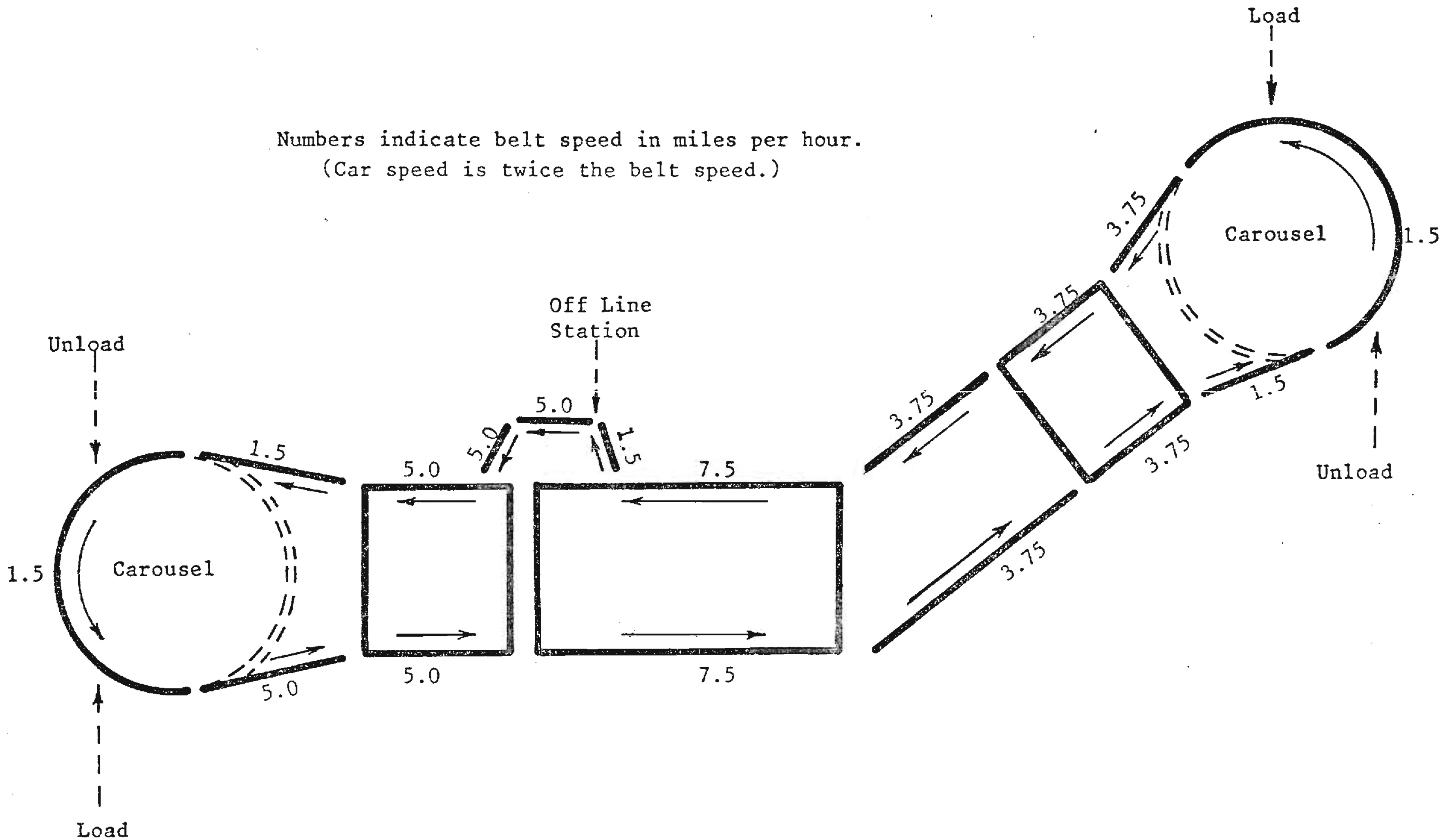

Figure 2. Drive belt schematic.

IV. HISTORY OF THE PROGRAM

The first few months of installation went ahead of schedule and within budget estimates. A change in the track route from the western terminal, together with inflation, started the beginning of delays and over-extension of the budget. Subsequently the termination date of the contract was extended from 31 December 1975 to 31 December 1976. Below is an outline of program activities.

<u>June - September 1974</u>

- Transette, Inc. organized.
- Detailed engineering plans started.
- Contract formalized between Georgia Tech and Transette, Inc.
- Site prepared for pouring of concrete.
- Design and fabrication planned for cars.

<u>October - December 1974</u>

- Final verification test plan agreed upon by TSC, NSF, Georgia Tech and Transette, Inc.
- Pouring of concrete slab completed.
- Mechanical equipment pits poured.
- Pit drains, supports and covers fitted and placed.
- Motor supports fabricated.

<u>January - March 1975</u>

- Solid state logic system approved by Westinghouse.
- Door and window frames fabricated.
- Main chassis frame fabricated and assembled.
- Drive pulleys fabricated.
- Guide rails cut and crossties welded.
- Two dollies and hoists fabricated for ease of two-man placement of guide rail sections.
- Fabrication of cars begun: two assembled.
- Control house fabricated and installed.
- Site graded for proper drainage.

April - June 1975

- Idler pulleys installed and aligned.
- Control console and equipment cabinets installed in control house.
- Service wiring installed.

July - September 1975

- Fencing around the track completed.
- Guide rail sections bolted to concrete.
- Guide rail expansion joints fabricated.
- Carousel drive assemblies completed.
- Interior wiring of control house completed.
- Solid state logic equipment assembled and wired.
- Proximity sensor boxes fabricated.
- Rear axle assembled.
- Door operator fabricated and assembled.
- Air shocks mounted between running gear and and car body.
- Guide wheel sub-assemblies fabricated and assembled.

October - December 1975

- First car completed and displayed at Georgia Tech.
- Transette, Inc. requested a time extension.

January - March 1976

- Georgia Tech requested time extension and additional funds from NSF.
- Conduit run to control house.
- Carousels mounted.
- Track sections to carousels and off-line station mounted.
- Motors installed in pits.

April - June 1976

- Program extension approved by NSF.
- Sensor wire pulled.
- Conduit brackets mounted to concrete.

July - September 1976

- Wiring completed.
- New carousels constructed.
- Nylon drive pulley bushings replaced with oilite bearings.
- Oilite bearings replaced with roller bearings on continuous drive belt drive pulleys.
- Molybdenum polydisulfide applied to slider bed.
- Door opening mechanism simplified.

October - December 1976

- DOT, TSC team came to test system. (See Note 1.)
- Belts of two longest sections replaced with new, thinner belts of different composition.
- Two longest belt sections replaced with original belt.
- NSF informed that the system was ready to be tested.

As fabrication and installation progressed, design changes were made. Some changes were not necessary for the operation or testing program, but according to Dr. Sutton of Transette, Inc., would result in better overall design and operation of the system. Engineering Experiment Station staff feel that considerable time was wasted in making changes to all eight cars or to all track sections, rather than testing a change in one car or track section before completing the remainder of the changes.

Other problems which resulted in very costly time delays and expense derived from misrepresentation of product capabilities. For example, three types of bushings were tested in the belt drive pulleys before bushings capable of taking the loads required were found. According to the manufacturer, all three types should have taken the load requirements.

Note 1. On 19 October during the tests, the lagging on the drive pulley of one belt section was worn away due to unusual forces produced when a car was pushed onto the belt from the curve section. When the TSC test team was informed that it would take approximately one day to replace the lagging, they decided to terminate the tests until some unspecified date. The lagging was replaced on schedule. The tests could, therefore, have been resumed with minimal delay had the TSC test team been willing to accept a short interruption.

The most costly problems, with respect to time and money, were those involving the drive belt. The construction of the belt was represented by the manufacturer as having a lower surface which would slide freely on the stainless steel slider bed, if there was water on the slider bed. The belt also was not supposed to deform or stretch as the result of the tensions required. In fact, however, the belt material did stretch, causing lagging on the drive pulleys to be worn away frequently. The lagging was also worn away if there was water on the slider bed when the belt was turned on; apparently air pockets formed, which acted as suction cups. Under tension, the belt sides curled up to such an extent that the edges rubbed against a wood lip installed over the slider bed to prevent the belt from coming out of the slider bed. The belt manufacturer then suggested using a different belt; this belt was installed, and after running for a short period of time, folded in half lengthwise. The lower surface of the original belt was then sanded off, and it was tested again, with somewhat better results.

Due to forseeable problems with pulley alignment, the belts for the curve section of the track were not installed. It was hoped that a car would have enough momentum to coast through that section and continue onto the next belt section. However, the radius of curvature at the beginning and end of the guide rail section was small enough to cause considerable friction between the guide wheels and guide rail. This resulted in enough loss of momentum to prevent the car from coasting onto the next belt. The section of guide rail was replaced with one having a larger radius of curvature at both ends. When the system was tested with the new guide rail, a car needed only a little prompting to reach the next belt section.

Another problem area which was not resolved due to lack of funds was the carousels. Again the radius of curvature was so small that enough friction was produced that a car could not travel around the carousel without being pushed. In this case, the friction was between the guide rail of the carousel and the side of the drive wheel which was pulled against the guide rail because of the alignment of the guide wheels. According to Dr. Sutton, this problem can be eliminated by offsetting the guide wheels.

The logic system was successfully bench-tested and later in large degree successfully tested at the test site. Several wiring problems were discovered, which prevented a thorough test before work was halted due lack of funds.

Two time extensions were granted to allow Transette, Inc. additional time to complete the installation.

During the period between 19 October 1976 and 28 December 1976, several phone calls were made to TSC to try to establish a new test date. Although the installation had not been totally completed, the majority of the tests could have been made in accordance to the official test plan, "Transette Personal Rapid Transit System Test Plan," which had been agreed to on 31 October 1974, by NSF, TSC, Georgia Tech, and Transette, Inc. However, on 28 December 1976, TSC informed Georgia Tech and Transette, Inc., that they did not agree with the approved test plan and would not conduct the tests until they receiver written instructions from NSF to carry out the tests in accordance with the approved test plan.

Since Georgia Tech was unable to obtain a commitment from TSC during the time period of 19 October 1976 and 28 December 1976, NSF was formally notified on 28 December that the Transette System was ready to be tested in accordance with the 31 October 1974 test plan. Georgia Tech also reminded NSF that the tests needed to be completed as soon as possible since no money remained to conduct the tests.

Georgia Tech was informed that, on 29 December 1976, NSF requested that TSC initiate the testing program as soon as possible in accordance with the "Transette Personal Rapid Transit System Test Plan." However, from 29 December 1976 until 1 March 1977, there was no response from TSC. Therefore, official proceedings were begun on March 1, 1977 to close out the contract between Georgia Tech and Transette Inc., and the contract between Georgia Tech and NSF.

In summary, the majority of the installation was completed and tested on a limited basis with the exceptions of the carousels, curve section, and automatic mode, for reasons described above. The door-opening and off-line mechanisms, although not completely installed, appeared to operate as expected under limited testing. All parts of eight cars were fabricated but only two were assembled and tested. The drive belts did in fact drive a car at speeds twice that of the belts, thus demonstrating the technical feasibility of the basic design concept. Due to the lack of completion of the installation only limited testing was possible, therefore, it was not possible to determine the practicality in routine service the reliability and dependability of parts. Finally, due to the failure of the TSC team to complete their test program it was not possible for Georgia Tech personnel to obtain rider acceptance and evaluation of the system.

V. CONCLUSIONS

Although the entire installation was not completed and the TSC testing program was not conducted, the basic design concept of the Transette System was demonstrated as feasible, thus achieving one of the two goals of the program. Because of the installation deficiencies, the system never reached a degree of reliability such that it was capable of operation over a significant length of time. Thus, the goal of demonstrating satisfactory routine service and measuring operating cost and efficiency was not reached. Because the testing program was not completed, students were not allowed to ride the system and student evaluation was not obtained. The Georgia Tech technical staff members involved in the program feel, however, that the system is worthy of further testing and development.