SYSTEM OVERVIEW

MRM

SYSTEM ABSTRACT

The Morgantown People Mover is an Automated Guideway Transit system which provides personal rapid transit (PRT) service between the separated campuses of West Virginia University and the Central Business District. The system development and construction was funded by the Urban Mass Transportation Administration, and was completed in three phases (IA, IB, and II) over the period from 1971 to 1979. The system consists of a fleet of electrically powered, rubber-tired, passenger-carrying vehicles, operating on a dedicated guideway network at close headway (vehicle separation). The system provides a safe, comfortable, low polluting, reliable means of transportation. The system features year-round operation, as well as direct origin to destination service.

As the first urban deployment of Automated Guideway Transit technology, the objectives of the system are to:

- Demonstate the technological, operational and economic feasibility of a fully automatic urban transportation system.
- Determine, through system evaluation and operational experience, the potential applicability of personal rapid transit to national needs.
- Qualify the system as a candidate for use in other locations.
- Provide a functional and economic transportation system for the University of West Virginia.

The Phase I system was developed under the auspices of the Urban Mass Transportation Administration (UMTA) by the Boeing Aerospace Company, the System Manager. The Phase II UMTA capital grant expansion was under the direction of the West Virginia Board of Regents (WVBOR).

The Phase I development team included the following major contractors and subcontractors:

The Boeing Aerospace Co - System Management & Integration & Vehicles.

F.R. Harris - A & E Design

The Bendix Company - Station Electronics

The Trumbull Corp. - General Contractor

The Melborne Corp. - General Contractor

The Irey Corp. - General Contractor

Barnes & Brass Corp. - General Contractor

Phase II expansion was accomplished by the following team:

West Virginia Board of Regents - System Management

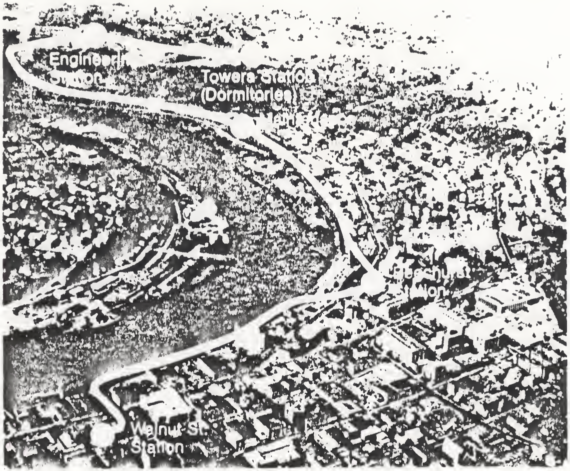
The Boeing Aerospace Co. - Station Electronics, Vehicles, Guideway & Station Equipment Installation, and System Checkout.

F.R. Harris - A & E Design

The Trumbull Corp. - General Contractor

Daniel, Mann, Johnson & Mendenhall (DMJM) - Consultants to WVBOR.

MORGANTOWN PRT ROUTE



SYSTEM OPERATIONAL DESCRIPTION

The Morgantown PRT system is operated in either schedule or demand mode. During those periods when passenger demand is highly predictable, the system is operated in schedule mode. Vehicles are dispatched between origin/destination pairs on a preset schedule. When passenger demand is less predictable, the system is operated in demand mode. Vehicles are then dispatched only in response to a passenger request. Passenger actions upon entering the system are always the same regardless of the mode in which the system is operating.

Operation of the PRT system, as summarized from a passenger's viewpoint, is as follows: arrive on concourse level of origin station where static and dynamic displays provide direction to the platform servicing his destination; proceed to the platform level; insert a coded card or exact change in a fare gate and press a button selecting destination. A gate display illuminates informing passenger to "proceed" to the vehicle loading area. A Vehicle Destination Display above the loading gate provides vehicle boarding instructions. If assistance is needed for any reason, a dedicated telephone link to the central operator is available near each entry gate area. The passenger is kept informed of changes in the system operating status via station public address system.

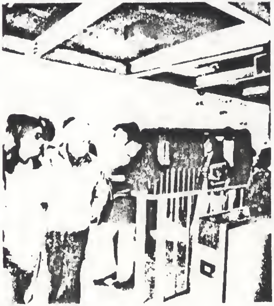
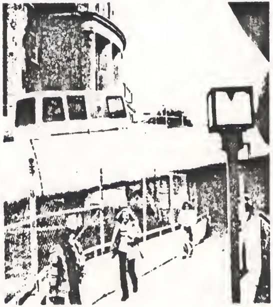
The passenger boards a vehicle when it arrives at the loading gate, and the display indicates the vehicle is assigned to his destination. The door closes and the vehicle automatically proceeds to his destination. At the destination station the vehicle stops at an unloading gate, the door opens and the passenger leaves the station through an exit gate.

Elevator service is provided from station concourse levels to each platform to permit use of the system by the handicapped and elderly.

The operation of the system elements required for the passenger service described above, is provided in the following discussions.





PRT SYSTEM ELEMENTS

The Morgantown PRT System consists of three major system elements.

Structures and Power Distribution System

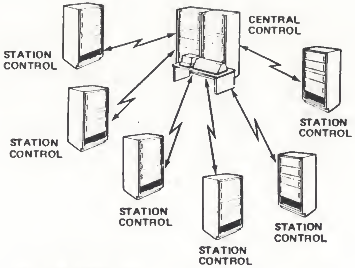
Includes the guideway structure, passenger stations, co-located maintenance and central control facilities, guideway heating, the electrical power distribution system, and a small auxiliary maintenance and wash facility.

Control and Communications System

Includes the Central Control and Communications System (CCCS), Station Control and Communications System (SCCS), and Guideway Control and Communications System (GCCS).

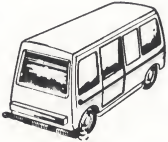
Vehicle System

Includes all the vehicles in the system.



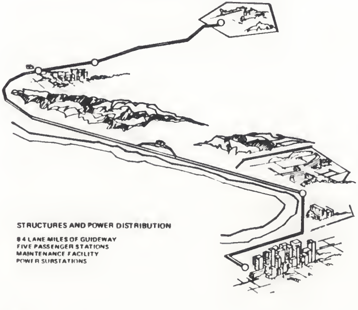
CONTROL AND COMMUNICATIONS

CENTRAL CONTROL
CENTRAL COMPUTER AND ELECTRONICS
SIX STATION COMPUTERS AND ELECTRONICS



VEHICLE

ELECTRIC POWERED
AIR CUSHIONED
21 PASSENGERS
8,700 LB EMPTY
15.5 FT LONG



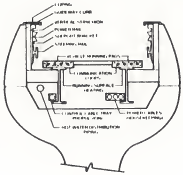
STRUCTURES AND POWER DISTRIBUTION

8.4 LANE MILES OF GUIDEWAY
FIVE PASSENGER STATIONS
MAINTENANCE FACILITY
POWER SUBSTATIONS

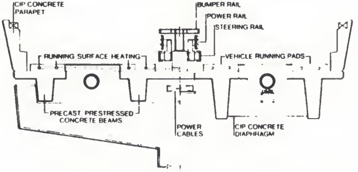
GUIDEWAY

The guideway structure is a limited access route connecting the PRT stations and the maintenance facility. Approximately 54% of the guideway is elevated, the remainder at ground level. Both single and double lane guideways exist. The running surface is concrete containing distribution piping for guideway heating to allow all-weather operation. Inductive communication loops, also contained in the running surface, enable messages to be transmitted and received between the vehicle and the control and communications equipment. Steering and electrical power rails are mounted vertically along the side of the guideway. Emergency walkways, handrails and guideway lighting are provided for passenger safety if egress is required.

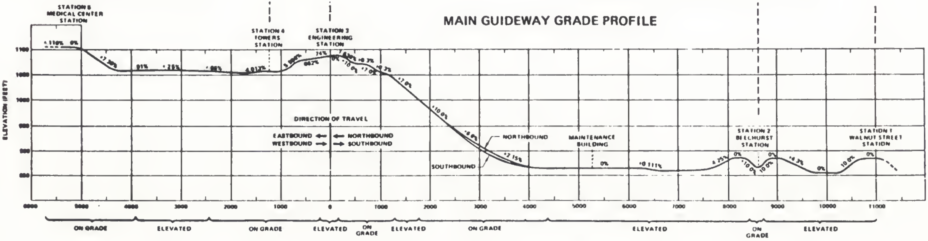
A total of 45,936 linear feet of guideway network is installed with grades up to 10%. Curves that are super-elevated as well as spiraled offer comfortable ride characteristics. Thirty-foot radius curves are used in station areas resulting in compact station design. Guideway speeds up to 30 miles per hour enable passengers to depart from downtown (Walnut Street Station) and arrive 10.5 minutes later at the Medical Center Station, a distance of 3.6 miles, any time of day or night. With an average speed of 14 miles per hour, a time savings up to 15 minutes is achieved.



TYPICAL GUIDEWAY CROSS SECTION (ELEVATED) – PHASE I



TYPICAL GUIDEWAY CROSS SECTION (ELEVATED) – PHASE II



MAIN GUIDEWAY GRADE PROFILE

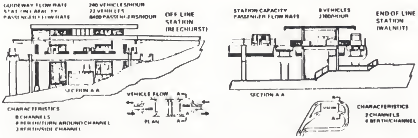
PASSENGER STATIONS

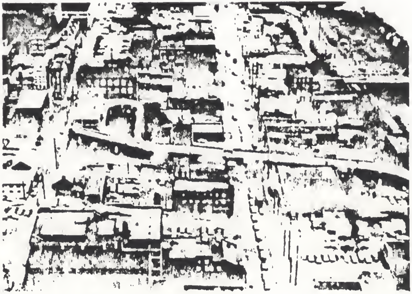
The station facilities provide access to the system, directing passengers to and from the vehicle loading areas. The facilities also house control and communications equipment required for controlling vehicle operations within the station area.

Two types of passenger stations are utilized, end-of-line and off-line. As the name indicates, end-of-line stations are located at the extremities of the system (Walnut and Medical Center). The off-line stations (Beechurst, Engineering & Towers), allow vehicles to either bypass or stop, providing passenger non-stop service. All stations have two levels, the entry or concourse level and the loading platform level. This eliminates interference of vehicle and passenger movement. Each platform channel has one loading position and two or three unloading positions, (depending upon length).

Passengers entering the station on the concourse or street level are directed to the proper platform by the Platform Assignment Display. A stairway or ramp to the loading platform level introduces the passenger to the Morgantown MPM II system. The stations are designed to provide full passenger service without a station attendant.

MORGANTOWN PRT PASSENGER STATIONS





MAINTENANCE FACILITY

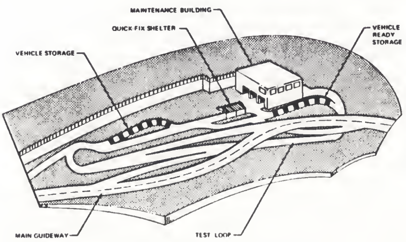
The maintenance facility provides for operation, maintenance, test, cleaning and storage of vehicles in the Morgantown PRT system. The facility consists of a maintenance building and associated guideway. The building houses maintenance shops, a central control room and the communications equipment and personnel necessary to operate and maintain the system. The associated maintenance guideway contains a test loop for post maintenance check.

The facility permits complete vehicle maintenance, repair, cleaning and test activities including: lubrication, detail inspection, vehicle repair, mechanical/electrical maintenance, functional testing, vehicle storage, etc. Repair of electronic and hydraulic/pneumatic equipment is accomplished in separate maintenance shops within the building. All vehicle subsystem components are maintained and repaired in the vehicle maintenance area with the exception of emergency repairs made at stations or on the guideway. Malfunctioning electrical and mechanical station equipment will be removed and transported to the maintenance facility for repair.

ENGINEERING MAINTENANCE FACILITY

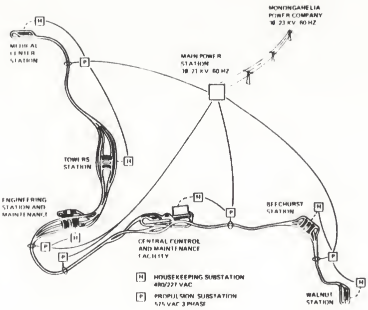
This small facility is located at the engineering station. It contains an automatic car wash, a "quick-fix" location for minor vehicle repair and ECU repair shop. This facility has an associated guideway, providing 8 parking spaces for ready vehicles. The crew manning this facility responds to anomaly situations in the north end of the system, thus minimizing system impact (downtime).

MAINTENANCE FACILITY



ELECTRICAL POWER DISTRIBUTION SYSTEM

The electrical power distribution system provides the prime power necessary to operate the Morgantown PRT system. The power system consists of a main power substation, propulsion power substations, housekeeping power substations, uninterruptable power supplies and standby power generators. Electrical power is used for vehicle propulsion because of its low polluting qualities and its adaptability to the automatic control system.



The system receives 23kV, three-phase, 60 Hertz power from the Monongahela Power Company via overhead transmission lines to the main power substation. The main power substation distributes the 23kV power underground to each of the three propulsion substations located along the guideway and to housekeeping substations located at each station facility. The propulsion substations transform the 23kV input power to 575 VAC, three-phase, delta power for distribution to the guideway power rails. The propulsion substations are connected in parallel to the guideway at selected intervals. This assures proper voltage regulation is maintained along the guideway at peak operating loads. The housekeeping power substations supply 480/277 VAC, three-phase power to the passenger stations and to the maintenance facility for heating, lighting, air conditioning, displays and the uninterruptable power supplies.

Uninterruptable power supplies are used for control and communications system power during main power drop-outs. Standby power generation is provided for critical surveillance equipment, guideway and facilities lighting if normal power is lost.

CONTROL AND COMMUNICATIONS SYSTEM

The primary purpose of the Control and Communications System (C&CS) is to provide automatic control, communications and monitoring of the movement of vehicles along the guideway.

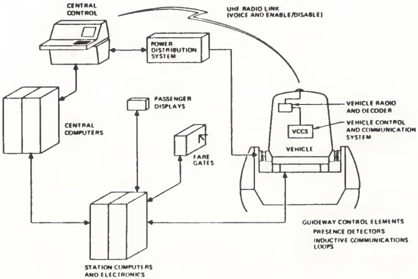
The C&CS controls vehicle movements on the main guideway, within each station area, at guideway and station interchanges and at the maintenance facilities. All communications, commands, station signals, and the management thereof are the responsibility of the C&CS which also provides dynamic graphics and other communications for passenger assistance.

The C&CS consists of dual central supervisory computers, dual station control computers, and the communication links between central control and each station. The C&CS also includes guideway and onboard vehicle control and communications equipment. The C&CS is divided into the following functional areas:

1) CCCS–Central Control and Communications Subsystem
2) SCCS–Station Control and Communications Subsystem
3) GCCS–Guideway Control and Communications Subsystem

The central computer carries out the automatic system management functions, receiving destination service requests from the stations and transmitting commands to the stations. Duplex communications with the stations is through asynchronous 2400 bit per second data lines. The interface between computers is through standard modems at both central control and the stations. The station computer receives inputs from the destination selection units and provides passenger instructions via the passenger advisory displays. The station computer manages vehicle movements and receives status information via the data handling unit. Speed commands, station stop commands, steering switch signals, and calibration signals are received by the vehicle through inductive communication loops buried in the guideway.

Redundant computers with automatic switch-over capability are provided at each computer location in the event of failure of a primary computer.



CENTRAL CONTROL AND COMMUNICATIONS CHARACTERISTICS

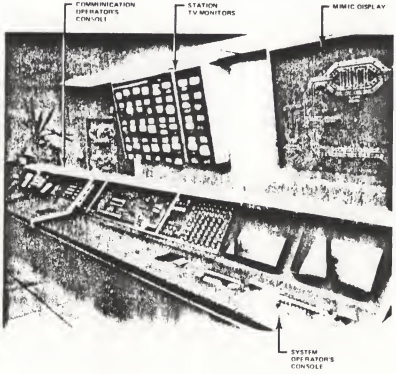
The central control equipment includes the central computers, peripherals, control console/displays, and communications equipment. The system operators, located at central control, monitor and exercise direct control over the system during conditions of initialization, failure, or shutdown. At all other times, the central computer provides control and supervision of vehicles in the station, on the guideway and at the maintenance facility. The system operators merely monitor the operation. All commands are routed from the central control console through the central control computer to the remote computers located at each facility. The operators can call on certain software routines by typing the required message on a control console keyboard.

Software routines allow the operator to restart the system, run vehicles at reduced performance levels, assign vehicles to various locations, and perform other system control and override actions. Performance level modification involves running the vehicles at speeds lower than normal for use during abnormal or emergency conditions.

In the scheduled mode of operation, the central computer manages vehicles by assigning destinations and dispatch times to each vehicle in the system. The passenger enters the station and boards a vehicle assigned to his destination. In the demand mode, the central computer allocates vehicles only if the number of vehicles within the station is inadequate for handling passenger demands. Dispatch times are assigned by the central computer in both the schedule and demand modes to ensure that no conflicts exist at guideway merge points between vehicles enroute to their destinations.

The central console equipment permits the operators to monitor and control the transit system. The consoles include display and control equipment, as well as communications equipment. The central control room also includes a mimic display which permits the operators to monitor the progress of each vehicle operating in the system, and closed circuit TV monitors for system security and passenger safety.

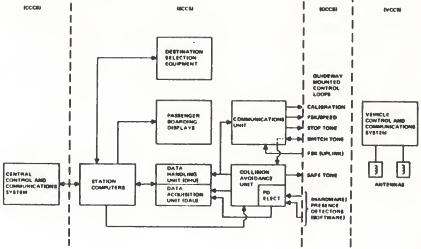
CENTRAL CONTROL ROOM



STATION CONTROL AND COMMUNICATIONS CHARACTERISTICS

The Station Control and Communications Subsystem (SCCS) controls vehicles and station operations in response to central supervisory commands. Communication of control signals to the vehicle is accomplished through inductive communication loops imbedded in the guideway. Communication is in the form of coded messages and fixed frequency control tones. The station computer controls vehicle switching, stopping, and door operations in the station. The station computer also operates the station dynamic boarding displays and responds to inputs from the passenger activated destination selection units. The computer in the maintenance facility performs the same types of functions as the station computer and also controls the test track and maintenance "ready" storage positions.

Each station has a Collision Avoidance System (CAS) which acts to prevent vehicle collisions in case the primary Vehicle Command and Control System should fail. The principal elements of CAS consist of redundant sensors which detect vehicle entry into a control block; inductive communication loops which transmit a safe tone to the vehicle in a block; and redundant control electronics (and software) which determine correct occupancy of the block. As a vehicle progresses along the guideway, the CAS control electronics removes safe tone from the block immediately behind. If a trailing vehicle violates the "OFF" block, it stops automatically by activation of emergency brakes. In each leg of a guideway merge area, one safe tone is normally off. This safe tone is turned on allowing a vehicle to proceed when vehicle priority at the merge is established by the CAS control electronics. At each switch point on the guideway, one safe tone is normally off. This safe tone is turned on allowing the vehicle to proceed when verification of proper switching action has been received.



GUIDEWAY CONTROL AND COMMUNICATION CHARACTERISTICS

The Guideway Control and Communications Subsystem (GCCS) consists of the equipment installed on the guideway. This equipment includes digital data cables, tone signal cables, passive presence detectors, and the cable and hardware required to connect the GCCS equipment to the SCCS equipment. All active electronics which drive the cabling are located in station and maintenance facility SCCS equipment rooms. Station generated commands are inductively coupled to the vehicle from the loops buried in the guideway surface. The function of these guideway mounted control loops is as follows:

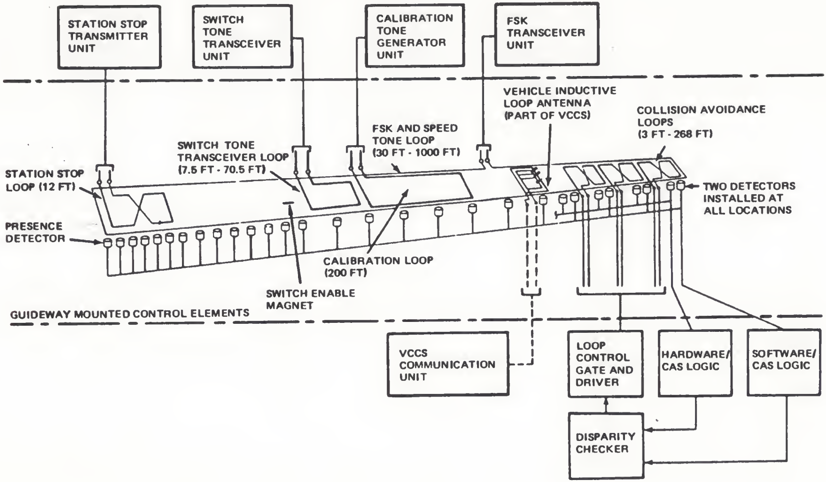
Station Stop Loops. The station stop tone transmitter generates a signal to decelerate and stop the vehicle ±6 inches from the center of the station platform unloading/loading gates. The vehicle enters the stop loop at 4 feet per second and is decelerated to a precise stop as brakes are applied.

Switch Tone Loops. The switch tone transmitter generates a signal to command the vehicle to "steer left" or "steer right." The vehicle is sent a switch command at every guideway juncture (merge and demerge). The vehicle must verify that switching has been accomplished or it is brought to a stop.

Calibration Loops. The calibration tone generator transmits a signal to the vehicle to provide measured distance reference. This nonvital signal is used by the VCCS as a reference for calibrating the vehicle's odometer. The vehicle measures distance traveled and calibrates the odometer, removing any error accumulated since the last loop.

Frequency Shift Keying (FSK) and Speed Tone Loops. The FSK transceiver unit transmits performance level, brake commands, door commands and identification requests to the vehicles operating in the system. These commands are transmitted over one set of loops. A second set of loops is used for receiving vehicle identification, door responses and fault status.

GUIDEWAY CONTROL AND COMMUNICATIONS CHARACTERISTICS



VEHICLE CHARACTERISTICS

The Morgantown vehicle has ten major subsystems: passenger module, environmental control unit, chassis, hydraulics, pneumatics, electrical power, propulsion, steering, braking, and vehicle control and communication systems.

Commands are transmitted to the vehicle from communication loops buried in the surface of the guideway and are received by the onboard vehicle control and communications system (VCCS). The commands operate the vehicle motor, brakes, steering and doors. Three-phase, 575VAC electrical power is received from the power rail, rectified, and controlled for the operation of the 70 horsepower, DC motor. The electrical power also operates the lights, air conditioner, hydraulic and pneumatic pumps, control system, and also charges the batteries. The pneumatic system provides an automatic vehicle leveling control. The vehicle is powered from guideway wayside power rails, through a passive run-on, run-off power collector mounted on the front wheel spindle which contacts the guideway power rail. The redundant four-wheel disc brakes are hydraulically operated in response to input commands and are actuated automatically under emergency conditions. Independent parking brakes operate when the hydraulic pressure is below a safe level. Guide wheels control the steering of the vehicle via the hydraulic, four-wheel, power-steering subsystem. Normal door operation is electrical in response to input commands from the Control and Communication System (C&CS).

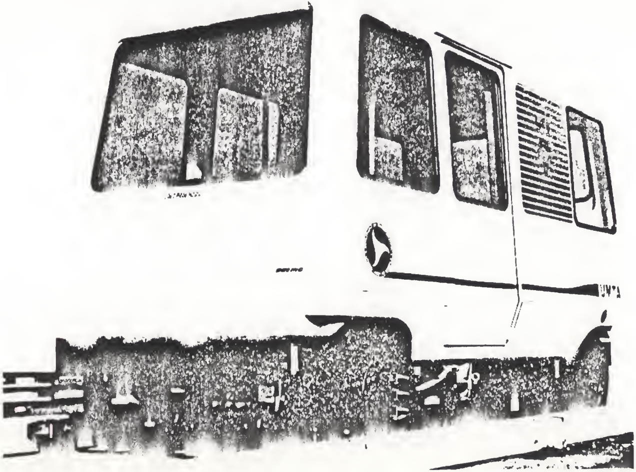
PHYSICAL CHARACTERISTICS

Length	15 Ft 6 In.
Height	8 Ft 9 In.
Width	6 Ft 8 In.
Weight	8,750 lbs Empty
Wheel Base	127 In.
Tread Width	62 In.
Accommodations	21 Passengers

PERFORMANCE CHARACTERISTICS

Control	Automatic-Remote
Propulsion	70 HP Electric Motor
Velocity	44 fps (30 mph) Max
Suspension	Air Bag-Automatic Leveling
Tires	Dual Chamber (1.5 In. Deflation)
Steering	Side Sensing (1.2 Sec Transfer)
Brakes	Redundant Dual-Piston Caliper
Conveniences	Environmentally Controlled, Quiet, Comfortable, Safe
Turning	30 Foot Radius

MORGANTOWN PRT VEHICLE



VEHICLE CONTROL AND COMMUNICATIONS CHARACTERISTICS

The Vehicle Control and Communications Subsystem (VCCS) is that portion of the automatic control system which is carried onboard the vehicle. The VCCS controls vehicle movements and operations from commands generated by the Station Control and Communications Subsystem (SCCS); it also identifies and transmits vehicle status to the SCCS. The data interface between the VCCS and the SCCS is an inductive communications link via the Guideway Control and Communications Subsystem (GCCS) over which vital signals are transmitted by tones and nonvital signals are transmitted by digital messages. The VCCS consists of 1) antennas, 2) communications unit, 3) data handling unit, 4) control unit, and 5) support unit, which perform the following functions:

Antenna–Two antenna assemblies provide the VCCS two-way communication with the C&CS through buried loops in the guideway. There is one dual antenna assembly for receiving and one antenna for transmitting low frequency electromagnetic signals. The antennas are mechanically fixed to the vehicle and electrically linked to the VCCS.

Communications Unit –The communications unit receives low frequency signals from the receiving antenna. These signals are conditioned and transferred to the data handling unit. The communications unit also receives signals from the data handling unit; conditions and transmits them through the transmitting antenna to the guideway.

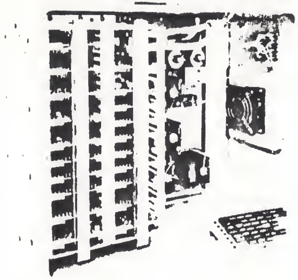
Data Handling Unit–The data handling unit (DHU) receives conditioned logic signals from the communications unit. The DHU decodes the signals and produces logical instruction and response sequences unique to the input. This unit will initiate logic commands and messages when vehicle conditions change.

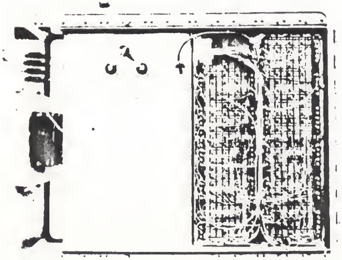
Control Unit–The control unit reacts to signals from the vehicle and the DHU to control the following vehicle functions:

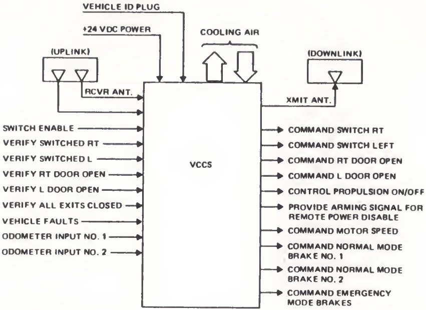
1) Brakes
2) Steering
3) Doors
4) Propulsion

Support Unit–The support unit provides synchronization of logic signals between units, power conditioners, test circuit isolation and interface signal receivers and transmitters.

VEHICLE CONTROL AND COMMUNICATIONS CHARACTERISTICS







S/GCCS/VEHICLE → VCCS

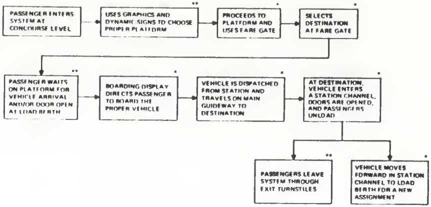
UPLINK
- SPEED TONES
- SAFE TONE
- SWITCH TONE
- STA STOP/CAL TONE
- FSK
  - DOOR COMMANDS
  - EMER BRAKE

VCCS → VEHICLE/SCCS

DOWNLINK
- SWITCH VERIFY
- FSK
  - DOOR STATUS
  - VEHICLE FAULTS

SYSTEM OPERATIONAL LOGIC

The system is designed to efficiently and safely move people between the five passenger stations. The chart shows the series of passenger-oriented events which occur during a typical trip. Each passenger destination request is logged into the software by the Destination Selection Unit (DSU) which is part of the Fare Gate. The Fare Gate accepts coins or magnetic fare cards. These cards are periodically issued to students. A vehicle is supplied by the system through either the demand mode or scheduled mode logic, and the passenger rides to the selected destination. While a passenger is in the system, there is continuous monitoring by either the system software or operator TV surveillance.



*THESE FUNCTIONS ARE UNDER SYSTEM/SOFTWARE CONTROL

**THESE FUNCTIONS ARE UNDER OPERATOR CONTROL/TV SURVEILLANCE

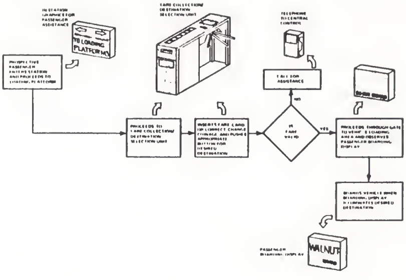
PASSENGER DESTINATION REQUEST

At single platform stations, i.e., Walnut Street and Medical Center, a passenger enters the station on a concourse level and proceeds to a platform level. At Beechurst, Towers and Engineering stations, which have two platforms, a lighted Platform Assignment Display on the concourse level directs the passenger to the proper platform to obtain service to his desired destination. The Platform Assignment Display is controlled by the system operator.

Use of a coded magnetic card or correct change coins are required at the Fare Collection Unit for passage through the entrance gate. A multi-trip card is issued periodically to students, or may be purchased from West Virginia University. The Fare Collection Unit is initialized periodically to recognize valid coded cards and to reject obsolete cards. A valid fare enables the Destination Selection Unit and the entrance gate.

After the passenger has inserted his card or fare into the Fare Collection Unit, he pushes the button for his desired destination. A legend lights to acknowledge the selection. The passenger proceeds through the gate to the vehicle loading area. The Fare Collection and Destination Selection Unit is reset when the passenger proceeds through the entrance gate.

Station computer response to the destination request depends on the operating mode. During the scheduled mode the requests are forwarded to central for off-line improvement of the schedule. The passenger boards the next vehicle scheduled to his destination. During the demand mode the station computer begins a sequence of searches. The computer looks for an empty vehicle currently in the station loading position. If a vehicle is not available, the computer looks for an empty vehicle in the station and directs it to the loading position. Otherwise, the computer finds the nearest available vehicle and directs it to the loading position.



IN-STATION VEHICLE MANAGEMENT AND DISPATCH

The station computer system controls in-station vehicle movements with overall direction from the control center. Routing of an incoming vehicle to an unloading berth is based on: 1) channel assignment and station inventory policy, 2) the availability of an open berth.

The routing logic decisions are implemented at the station branch points by steering commands which direct the vehicle into the proper channel. Nominally, the vehicle is moving at 8 ft/sec during channel switching. Time delays for control system operation, steering response to commands, and switching verification must be accommodated in the distance available.

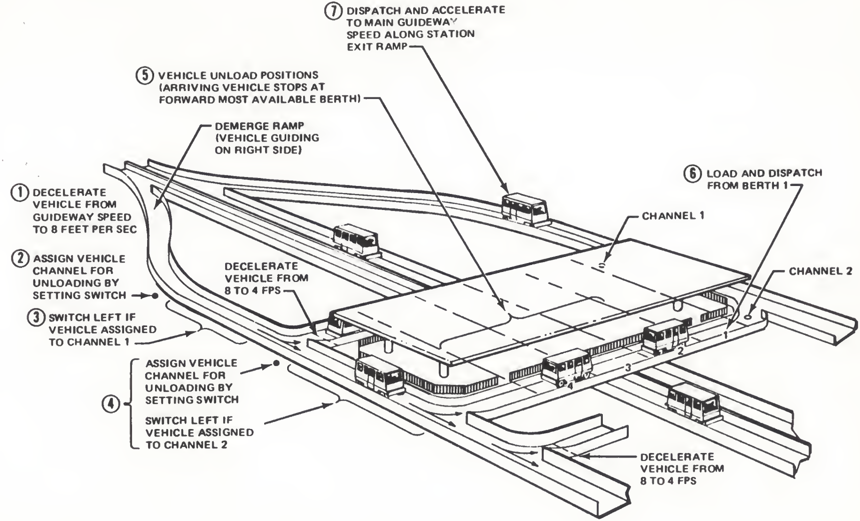
After the switching region is cleared, the vehicle is decelerated to the 4 ft/sec velocity from which a vehicle can execute a precise stop (± 6 inch accuracy). Stopping deceleration is controlled by an on-board speed profile. The vehicle initiates the precise stop in response to an energized guideway stopping loop. The station computer commands energizing of the stopping loop at the channel location at which the vehicle is scheduled to unload.

In unloading positions, the door is commanded open for a preselected time to allow passengers to depart. The door is then automatically closed and the vehicle is commanded to "move up" to the forward position in the channel (loading position) and open its door (in the scheduled mode) or wait for a destination request (in the demand mode). The first empty car in a station channel may be sent to another station to meet demands if not required at this station. During the scheduled mode, vehicles are commanded to have station dwell times sufficient to unload, move up, and load to meet their scheduled departure. After the passengers have boarded and the allotted vehicle door open time has expired, the door is automatically closed and the vehicle is ready for dispatch. If, however, the sensors detect any object in the door opening, the door will automatically cycle open and delay dispatch until this condition is corrected. The station informs central of the vehicle destination, and requests a dispatch time from central. The dispatch time is determined so that a vehicle following the nominal dispatch profile for that station and starting position will merge on the guideway with its assigned moving slot position. The station is synchronized with central so that the system operates relative to a common time standard. The stop tone is removed from the stopping communication loop at dispatch time.

The vehicle accelerates to 8 ft/sec velocity. Switching commands direct the vehicle from the platform channel to the acceleration ramp. On the acceleration ramp the vehicle accelerates at 2 ft/sec^2 until main guideway speed is reached (22 or 33 feet per second).

Station control monitors dispatched vehicles on the acceleration ramp via presence detector data to assure that guideway speed is reached and that the assigned slot position is utilized. If the speed and position (time of presence detector actuation) are within tolerance, the vehicle is permitted to proceed to the main guideway. The vehicle steers right on the acceleration ramp past the merge point on the main guideway and is then commanded to steer left. The collision avoidance systems on the acceleration ramp and on the appropriate section of the main guideway are interlocked so that out-of-tolerance vehicles will initiate emergency braking.

IN-STATION VEHICLE MANAGEMENT



VEHICLES ON MAIN GUIDEWAY

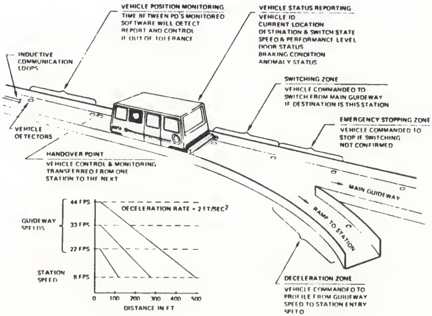
Vehicle progress on the guideway is monitored by the station control computer by observing the time of actuation of presence detectors. Vehicle status is also monitored by station control. A vehicle status report includes: 1) vehicle ID, 2) current location, 3) current destination and switch condition, 4) speed performance level, 5) current civil speed command, 6) door status, 7) braking condition, and 8) any current anomaly. Status data are periodically transmitted to central for overall system monitoring and for control of handover from station to station.

Responsibility for detailed vehicle management is transferred from one station to the next at a particular guideway presence detector. Central control informs the receiving station of the enroute vehicle's identification, destination, status, and assigned guideway slot. When the vehicle arrives at the guideway section boundary presence detector, the receiving station performs the position and fault report monitoring tasks.

Civil speed is 22, 33, or 44 feet per second on different sections of the main guideway. A speed change is commanded by a frequency change in the speed tone at two adjacent speed tone communication loops. This frequency change is detected by the VCCS and a standard 2 ft/sec^2 speed transition is accomplished. A smooth, controlled transition is effected to the new speed.

As the vehicle approaches each enroute station, the software determines if the vehicle should be switched into the station. The availability of an open unloading berth in the station is checked. If no space is available at an on-line station, the vehicle is stopped on the ramp until a space opens. If no space is available at an off-line station, the station is bypassed. The central operator is notified to take appropriate action to return passengers to their selected destination. Under normal operating conditions, an unloading berth will be available and a switching command is sent to exit the vehicle from the main guideway to the destination station. Verification that positive switching action has been completed is provided to the station by the vehicle. Failure to receive switching verification initiates braking.

GUIDEWAY CONTROL AND MONITORING



SYSTEM OPERATIONS AND MAINTENANCE

System operations and maintenance activities are performed at the two maintenance facilities. A team of highly trained engineers and technicians operates and maintains the system to the highest standards of safety and passenger service.

The organizational concept for this team is shown below along with the functional allocation of their duties.

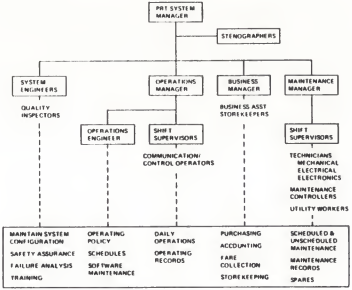
The System engineers are responsible for overall cognizance of system operational readiness, safety, and quality inspection.

The Operations crew provides daily operations through teams of two operators and one shift supervisor who constantly monitor system performance and manage the system's recovery from anomalous events.

The Maintenance crew performs scheduled maintenance on all system elements and provides the troubleshooting and repair function for unexpected failures (unscheduled maintenance).

The Business Manager's office provides the accounting and purchasing functions, as well as fare collection, and spare parts storekeeping.

OPERATIONS AND MAINTENANCE ORGANIZATIONAL CONCEPT



FUNCTIONAL ALLOCATION