P A R T IV

SCOPE OF SERVICES

SCOPE OF SERVICES
ON-CALL GENERAL SYSTEMS ENGINEERING
CONSULTANT SERVICES

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1 General:

1.1 Purpose:

The Washington Metropolitan Area Transit Authority (known hereinafter as the Authority) desires that certain professional on-call systems engineering consultant (GEC-SYS) services be secured to provide design and review services to support the on-going maintenance program, studies, provide engineering support for new technology development projects, and for additional projects and services as required. The systems covered in this contract include automatic fare collection, automatic train control, communications (excluding IT), hotel power (480 volts and below), trackwork???? and traction power.

As described in the following, the GEC-SYS shall assist the Authority by providing certain professional engineering services associated with current and new systems equipment, repair and maintenance procedures and or support for equipment located in the District of Columbia, Maryland and Virginia. This effort pertains to both Metrorail and Metrobus.

1.2 Background:

1.2.1 Automatic Fare Collection

1.2.1.1 Automatic Fare Collection (AFC) System

The Automatic Fare Collection System of the Washington Metropolitan Area Transit Authority ("WMATA" or "Authority") employs a self-service group of Farecard Vendors, Express Vendor (collectively referred to as Ticket Vendor Machines (TVM)), Exitfare Machines, Faregates, Parking Lot Equipment, and Bus Fareboxes to provide the services required for the transit customer to pay the fares and fees associated with the usage of the WMATA Metrobus and Metrorail transportation systems. In MetroRail, the Station Controller PC is located in the Station Managers kiosk on each Rail mezzanine. This allows WMATA staff to configure the mezzanine devices to best suit customer flow, to monitor the operation of these devices, and to transmit operational, statistical and transactional data to a central site.

1.2.1.2 Fare Media

The current Automatic Fare Collection System TVMs allow customers to purchase a magnetically encoded Farecard with value in nickel increments between configurable preset values, (2) a pass valid for a predetermined period starting on first use, or (3) to load funds onto a SmarTrip® Card. The SmarTrip® Card is a "type B" memory Contactless Smart Card (CSC) that uses the Cubic

Go-Card application. There is a project underway wherein all rail devices will use the Cubic Tri-Reader 2 (TR2) Card Interface Device (CID or "Target") and the Cubic Nextfare suite of software. The TR2 will be able to read and write to 3 different types of CSCs: Type A, Type B and Go Card. The TR2 can be upgraded with firmware/software to read smart cards complying with the ISO 14443 standard. There are also two Security Access Module (SAM) sockets that are designed to be programmable for operation in accordance with the latest Eurocard, MasterCard, and Visa (EMV) specifications. Metrobus fareboxes use the earlier generation Cubic Tri-Reader.

Transactions speeds between smart card and TR2 are to be no greater than 300 msec, this includes reading the information from the card, processing this information and re-encoding the information on the card. Read range between card and target is from 0 to 50 mm; although the customers are advised to "touch" their SmarTrip ® card to the target. The stored value and other data required for processing the transaction is stored on the SmarTrip® Card itself.

1.2.1.3 Vendors

A typical mezzanine configuration consists of Farecard Vendors and Express Vendors located on the free (street) side of the faregate array. The customer purchases a magnetically encoded farecard from a Vendor or uploads value onto the SmarTrip® card at a Vendor. The vendor accepts coins, paper currency, credit cards, debit cards and magnetic farecards for payment and issues coins for change. The value or pass-period is encoded on the magnetic card or onto the SmarTrip® Card. A pass may be issued for unlimited rides during either a preset period with pre-defined start and end dates or for unlimited rides during a preset duration starting when the pass is first used. A "Short Trip Pass" may be issued for unlimited rides that are no longer than a pre-set cost.

1.2.1.4 Exit Vendors

If the customer takes a ride longer than the pre-defined short trip, the customer is directed to the Exitfare machine to add additional funds. One or more Exitfare machines are located on the paid (train) side of the faregates. The Exitfare machine allows the customer to add value to his magnetic farecard in the event that the customer does not have enough value to exit that station.

1.2.1.5 Adding Value

Customers may add value to Smartrip or purchase magnetics at Express Vendors using cash, debit/credit, trade in of magnetic cards or Smartbenefits. ISO 8583 debit/credit messages are sent via the existing communications infrastructure from the Express Vendor to the WMATA ACI Base 24 debit/credit switch application on the central computer and then forwarded to the sponsoring bank for online authorization. The Express Vendor checks for valid card BIN numbers as well as controlling limits on maximum credit/debit value purchases. Smartbenefits is a WMATA application used to support the IRS transit benefit program and other electronic transfer of value onto a SmarTrip® card.

1.2.1.6 Fare Gates

The customer then takes the farecard or SmarTrip® card to the faregate which verifies that the card is valid, encodes onto the card the Point-of-Entry, Time-of-Entry and whether the system was in the Peak or Off-Peak period when the entry was made, returns the card to the customer and opens the barriers when the customer retrieves the card. The customer then proceeds to the train to travel to his or her destination. Upon exiting the station, the customer presents the farecard or SmarTrip® card to the faregate which, using the entry data on the Card, the faregate calculates (from a table within the gate) the fare to be deducted, subtracts the fare from the value on the card, encodes the updated data on the card, displays the value deducted from the card and the remaining value. Again, if the customer does not have sufficient Value on the Farecard, the customer must proceed to the Exitfare Machine to add additional value (funds) to the Card. SmarTrip® card customers with insufficient funds to exit can "go negative", i.e., they do not have to use an Exitfare machine to bring the cards stored value up to the required fare but instead are allowed to exit with the stored value indicating negative value. They have to add enough value to bring the stored value positive before the next entry transaction is allowed.

1.2.1.7 Fare Calculations

Fare calculations are based on the distance traveled and whether the journey commenced during Peak or Off-Peak periods. The system has the capability to allow the use of discount or special fare categories for specified groups (e.g. such as elderly, disabled, students or others). The Fare Structure is configured on the central system and published to the machines where it is stored in memory within each machine for use in fare calculations. Transfer credit is given, based on configurable parameters, for transferring from the regional bus system to the Metrorail system and vice versa. Transfer credit is also given for transfer among various WMATA and regional bus systems.

1.2.1.8 Parking Equipment

The parking lot equipment deducts the parking fee from the customer's SmarTrip® Card. A signal is sent to the barrier to allow the customer to drive into or out of the parking facility after the fee has been paid. Depending on local regulations, the parking fee may be collected before allowing entry into the parking facility or before allowing exit from the facility. Stored value for parking fees is not allowed to go negative.

1.2.1.9 Station Controller

The fare collection equipment on the rail mezzanine, including the parking lot equipment, is connected to a Station Controller located in the kiosk on the mezzanine level. The Station Controller is the hub of the communications for the equipment before the data is transmitted to the central site. Communications from the devices to the station controller is via RS422 multi-drop serial communications. Real-Time-Data is collected for each transaction, on the usage of each machine through registers, and on the status and operation of each piece of equipment. The transaction data and the register data are used, among other things, to detect missing transactions. Data collected is used for revenue reconciliation, status of the devices ridership statistics, customer service and to ensure all transactions are processed. Communications between the Station Controller and the central site is via Ethernet over a private fiber optic network operated by WMATA. (At the time of writing, conversion from System Network Architecture (SNA) to Ethernet is in process; conversion is expected to be completed by December 2009.) Ethernet from the station controller to the central computer will not be enabled until all stations are converted to Nextfare.

1.2.1.10 Bus Farebox

Each Metrobus has a farebox which allows customers to pay fares in cash or by use of a SmarTrip® card. The customer may deposit coins or currency into the farebox until an amount equal to the fare is deposited at which time the transaction is complete. Customers who use a SmarTrip® card to pay the fare would present the card to the target on the farebox. The processor would deduct the fare from the value on the card and command the target to encode the new value on the card. Buses of local agencies participating in the Regional Fare System have a bus fare system, including the fareboxes and Garage Controller that is functionally equivalent to the system at WMATA.

1.2.1.11 Negative Transactions

MetroBus SmarTrip® card customers with insufficient value to pay the boarding fee are similarly allowed to go negative. This feature works once each for bus and rail. In both cases, MetroRail and MetroBus, the respective mode of transportation has to be positive before it can go negative. This means only one negative stored value transaction per mode.

Each farebox collects data on each transaction, on the total amount of fares collected and on the operation of the farebox. The data is downloaded to a computer at the garage, the garage controller, via an optically coupled probe and a Radio Frequency Local Area Network (RF LAN) when the Metrobus is serviced upon its return to the garage. Fare policy data and operational data are sent from the central computer to the farebox using the RF transmission. Each Garage

Controller is connected to the central site for central consolidation of data.

1.2.1.12 Central Site

Data-Systems at the central site allow operators to produce reports on the use of individual SmarTrip® cards and on the use of each machine. There is an on-line verification of each credit card and each debit card used for the purchase of fare at the Express Vendors. Data on the current value of each SmarTrip® card is maintained in a central data base so that a customer's card may be replaced if it is reported lost or stolen. As appropriate, individual cards may be hotlisted rendering them invalid for use if fraud, loss or theft is reported. When a card is hotlisted, this status is encoded on the card and can only be removed at an appropriate customer service facility.

1.2.1.13 Servers

The AFC data system uses IBM AIX model p590 and p595 servers with Weblogic 10 and Oracle 10g third party software hosting the Cubic Nextfare Central System (NCS) applications.

1.2.1.14 New electronic Payment Program

WMATA has recently awarded a contract for the next generation fare collection system. This system is referred to as the New Electronic Payment Program and is based on open standards and technology.

1.2.2 Automatic Train Control

1.2.2.1 The Automatic Train Control System for the first 37 miles of the Regional METRO Rail System, the interlocking control for the major repair facility, the first 150 pairs of cars, and the operation control center were all procured under Contract 1Z2011. This Section briefly describes the ATC system provided by General Railway Signal Company in response to WMATA Contract 1Z2011, and subsequent revisions and additions to the ATC System.

1.2.2.2 The Automatic Train Protection (ATP) System is that part of the ATC System which provides protection against collisions and overspeed conditions. The ATP System also provides control of interlockings, route security through interlockings, and control of train door operation. Principal functions of the ATP System are Train Detection, Speed Command Selection, Speed Command Transmission, Interlocking Control and Security, Train Door Control, and all related carborne equipment to receive, decode, and safely act upon the ATP commands.

1.2.2.3 Train detection is provided by jointless audio frequency track circuits except in certain areas of special trackwork. Mainline track circuits are conventional with tuning unit and impedance bond mounted between the rails at the block boundary. Audio frequency track circuits in special trackwork areas use a shunt bar and loop to inject the signal into the rails and an untuned impedance bond to couple the signal from the rails to the receiver in a center-receive configuration. Balancing impedance type, 60- Hz track circuits are used in the diamond of double crossovers and in the crossover track of single crossovers.

1.2.2.4 The audio frequency track circuits use eight frequencies (two sets of four) for train detection purposes. Only one set of frequencies is used on a given track and the same set is not normally used on adjacent tracks. Audio frequency track circuits that have both the transmitter and receiver in the same room are adjusted for a shunting sensitivity. Track circuits that have the transmitter and receiver in separate rooms are adjusted for a shunting sensitivity

1.2.2.5 Speed command selection is via vital relay contacts. The selection contacts represent traffic locking, occupancy of track circuit for which the speed command transmitter is effective, occupancy of track circuits downstream of the speed command transmitter, occupancy of track circuits upstream of the speed command transmitter if these circuits are within a more restrictive civil speed zone and the more restrictive civil speed limit is less than 2200 feet upstream of the speed command transmitter, position of switches downstream of the speed command transmitter, status of signal clearing networks downstream of the speed command transmitter, position of switches upstream of the speed command transmitter, when the relative location of such switches can create a more restrictive civil speed limit and condition of temporary speed restriction control. Additional conditions as required to provide safe train separation, speed, and door control and to provide schedule control at station platforms and dispatching locations. Where track circuit occupancy and signal clearing network status must be transferred from one train control room to another for speed command selection purposes, such information transfer is accomplished via polar direct current line circuits. Typical speed command selection networks and typical room-to-room line circuits are shown in the Contract Drawings.

1.2.2.6 Speed command transmission is via one of two audio frequency carriers, 4550 Hz and 5525 Hz, ON/OFF AM modulated at one of five discrete frequency code rates. One additional code rate is used for the transmission of door opening commands. The speed selection network selects a code rate generator output to drive the modulator, and energizes a carrier generator, in accordance with the above code chart, to cause the appropriate command to be transmitted. In all areas, except special trackwork areas, speed command transmission is via the same transmitter as the train detection frequency. The transmitting equipment is shared between the train detection frequency and the selected speed command frequency on a time division multiplexing basis. The multiplexing is controlled by the selected code rate, which alternately keys the train detection and speed command frequencies. In special trackwork areas two speed command transmission methods are used. First, at shunt bar locations transmission is via the same equipment as the train detection frequency with the code rate slaved from the transmitter on the opposite side of the shunt bar. Second, at receive/receive locations and for the loops through 60 Hz track circuits, transmission is via an independent speed command transmitter, the output of which is directed through loop selection networks to energize the proper loop for the routing and position of the train.

1.2.2.7 Interlocking control and security is divided into eight categories 1) route initiation, 2) route completion, 3) time released approach locking, 4) route locking, 5) detector locking, 6) switch control and indication, 7) signal control and 8) loop control.

1.2.2.8 Route initiation is accomplished by identifying the desired route in terms of the entering signal and the exiting signal. Route initiation by local control panel, in this method of initiation, the first signal button actuated on the local Interlocking Control Panel identifies the entering signal and the second signal button actuated on the local panel identifies the exit. Assuming that the desired exit is available and no conflicts are detected, the result is an energized pushbutton stick (PBS) relay associated with the entering signal and an energized exit stick (XS) relay associated with the exiting signal. Route initiation by central control, in this method of initiation, the central control computer sends a route request, associated with the entering signal, to the local equipment. Receipt of this control causes the same action in the local equipment as the first actuation of a signal button. The local receipt of the first route request control is indicated back to central control. Receipt of the entrance received indication at central control keys the computer to stop sending the route request control associated with the entering signal and to start sending the route request associated with the exiting signal. Receipt of this second route request control causes the same action in the local equipment as the second actuation of a signal button. Route initiation by track circuit occupancy, in this method of route initiation, the presence of a train in certain track circuits causes wired logic to initiate a route which the train will subsequently accept. The wired logic provides for storage of route requests when a desired route cannot yet be initiated, priority determination, and determination of exiting signal when a choice exists. The result of this initiation method is an energized PBS relay associated with the entering signal and an energized XS relay associated with the exiting signal. This method of route initiation is used only at certain locations and can be enabled or inhibited from the local control panel or from central control. While this method of initiation is enabled, all other methods of initiation remain effective. In a variation of this method, the route request is not initiated until a "TRAIN READY" indication is received from the train occupying the track circuit. Route initiation by train identity, this method of initiation is the same as route initiation by track circuit occupancy, except that the trigger for an initiation request is the receipt of a train destination and the determination of the desired exiting signal is by the destination of the train. When this method is used, the transfer of the detected train destination information to Central must be coordinated with the occupancy of the designated ADVANCE APPROACH area by the train, and with route availability. Route nitiation by wayside pushbutton, in this method of route initiation, the desired route is defined by actuation of a pushbutton located at the entering signal. The entering signal is determined by physical location of the pushbutton box and the exiting signal is determined by which button in the box is actuated. The result is energization of a manual pushbutton stick (MPBS) relay associated with the entering signal and energization of an exit stick (XS) relay associated with the exiting signal. This method of route initiation is used only at certain signals, signals which also have initiation methods described in the preceding two methods, and is active at all times.

1.2.2.9 The five methods of route initiation described above are coordinated to protect against misrouting and lockups. Coordination includes: 1) Local-remote control to prevent both local control and central control from being active at the same time; 2) Lockout control to prevent any active initiation method from functioning while another method is being used to initiate a route and; 3) Time-out control to cancel an unidentified entering signal if an exit is not identified in a predetermined time. The initiation circuits also include a search of possible routes associated with a defined entering signal. The result of this search is the energization of an exit (EX) relay associated with each "allowable-exit" signal location. The EX relay associated with a given "allowable-exit" signal location must be energized before the XS relay associated with that signal can be energized to identify it as the exiting signal. All route initiation circuits are considered non-vital. Route completion, after the route initiation is completed by identifying both the entering signal (PBS relay energized) and the exiting signal (XS relay energized), the route completion circuits complete the route by: 1) Requesting the proper switch positions; 2) De-energizing the unselected EX relays; 3) Making a preliminary check of the route integrity; 4) Initiating the vital locking and; 5) Initiating the request for signal clearing.

1.2.2.10 Route completion is accomplished as follows: 1) The state of the search relays (BY and AY relays) and the identification of the exiting signal (XS relay) determines the desired position of each switch in the route. This information is used to request the proper switch positions by energizing the appropriate lever repeater (NLP and RLP) relays; 2) Energizing the lever repeater relays causes the EX relays for unselected exit signals to become de-energized because of the requests for switch positions that would conflict with those exiting signals. Energizing the lever repeater relays also causes the switches to be properly positioned by the switch control and indication circuits if it is safe to do so; 3) The identity of the entering signal, non-vital checks of switch correspondence, occupancy within the route, non-vital check of traffic availability beyond the exiting signal, and the identity of the exiting signal are used to provide a preliminary route integrity check. The result of this check is the energization of the Route Check Relay (RCR) associated with the entering signal and; 4) Energizing the RCR initiates the vital locking and signal clearing requests.

1.2.2.11 Time released approach locking is provided for all mainline signals. One such locking circuit is provided for each signal. This form of locking is initiated when the Route Check Relay (RCR) becomes energized and remains in effect until released by one of the following: 1) The signal is accepted by the train (two track release). 2) The signal is set to stop and no train is within the approach limits. 3) The signal is set to stop and a predetermined time has expired. The approach locking relay (ASR) circuits are arranged such that a momentary interruption of track circuit energy will not release the locking. This is accomplished by using "two track release", with the two track circuits (the last track within the interlocking, and the first track exiting the interlocking) driven from different branch fuses and by cross checking the ASR relays such that, if opposing ASR's are both de-energized, as would be the case with a dc bus failure, time must be run to release the locking.

1.2.2.12 Route locking is provided to maintain security of the route ahead of the train as it progresses through the interlocking. Route locking is initiated by the initiation of approach locking and is released when approach locking is released and there are no occupancies in the route. In some cases the route is divided into contiguous sections for route locking purposes and locking of the section(s) of the route behind the train are released (sectional route release) as the train progresses through the route. Route locking is performed by Route Stick Relays (ASR and RSR).

1.2.2.13 Detector locking is established by the track relay for the track circuit in which the switch is located and prevents switches from being thrown under a train. At interlockings with automatic route initiation, loss of shunt protection is provided by requiring track relays to be energized for a predetermined time before locking is released.

1.2.2.14 Switch control and indication control relays (NWZ and RWZ) are driven from the switch call relays (lever repeaters NLP and RLP) in the route completion network. The switch control relays are circuited to provide storage of the switch call, provide premature indication prevention, and prevent preconditioning.

1.2.2.15 The switch control repeater relays (NWZPR & RWZPR) are vital relays, primarily for maintenance convenience. The switch control repeater relays control pole changed energy to the switch operating relays (NWR and RWR) through lock stick relay (LSR) contacts. The lock stick relay contacts are wired to provide a short circuit across the switch operating relays when the lock stick relay is de-energized.

1.2.2.16 The lock stick relay (LSR) is used to provide switch stroke completion in the event that the lock relay (LR) becomes de-energized prior to completion of the switch stroke. Overload protection of the switch machine motor circuit is provided by the overload (stick) relay (OR), which has one coil in series with the motor circuit. The second coil is used as a stick coil and is energized through a front contact of the same (OR) relay from the drive circuit for the switch operating relays. The switch machine motor circuit is a two- wire, pole-changed circuit controlled by magnetic blow-out contacts on the switch operating relays (NWR & RWR). Switch position indication is controlled by a set of switch circuit controller contacts within the switch machine which are part of a two wire, pole changed circuit, driving a pair of biased switch repeater relays (NWPR and RWPR). Where two switch machines are operated as one, such as at a crossover, the indication circuit is controlled by the switch circuit controllers in both crossover switch machines to drive a single set of switch repeater relays. Switch correspondence relays (NWCR & RWCR) are provided to verify that the switch (position) repeater relays (NWPR & RWPR) are indicating that the applicable switch is in the position called for by it's switch control repeater relays (NWZPR & RWZPR).

1.2.2.17 Signals are controlled by vital home signal relays (HGR) which are energized by vital route check (RC) networks. The following checks are included in these route check networks: 1) Approach locking is in effect. 2) Route locking is in effect. 3) Traffic locking beyond the exit signal is in effect. 4) Lock and lock stick relays are de-energized. 5) Switches are in proper correspondence. 6) Route is not occupied. 7) Timers associated with release of locking are at zero time. 8) There has not been an overrun of a red signal at the interlocking. Where a number of control lines extend past a facing point signal location, route sensitive signal repeater relays are provided for use in the speed circuits. Signal lighting energy is controlled through front and back contacts of the home signal relays (HGR), and the two red lenses of the STOP aspect are independently lighted from different energy buses.

1.2.2.18 Loop control and selection circuits are provided to sequence the transmission of speed commands through interlockings. The circuits and sequencing are such that a speed command never appears behind a train and only one loop is energized downstream of the track circuit occupied by the train. Loop control circuits are organized to require that the signal be clear and a train be on the first track circuit in the approach before the sequence can begin. Overrun protection is provided to interrupt the sequence and stop the transmission of all speed commands within the interlocking in the event of an overrun of a red signal.

1.2.2.19 Train doors are controlled by commands transmitted via the vital, wayside-to-train command transmission system used for speed commands. Two commands are used; OPEN RIGHT DOORS and OPEN LEFT DOORS. The absence of either of these commands is interpreted as CLOSE DOORS. Door control commands can be transmitted only at block boundaries associated with platform ends. Block boundaries associated with side platform stations are equipped to transmit the OPEN RIGHT DOORS command at the normal traffic-leaving end and the OPEN LEFT DOORS at the normal traffic-entering end. Block boundaries associated with center platform stations are equipped to transmit the OPEN LEFT DOORS command at the normal traffic-leaving end and the OPEN RIGHT DOORS at the normal traffic-entering end. Carborne ATP equipment compensates for direction of travel of the controlling "A" car and ensures that it is safe to open the train doors prior to acting upon the commands. One of the safety checks made is the verification that the train is at a passenger station. This check is accomplished by cycling a bit back and forth between the train and the station via the TWC system. The cycling of the TWC bit is used to keep a vital relay (PSCR) on the train energized as long as the train is in TWC communications with a passenger station. The application of the door control commands is under control of the station dwell control circuits.

1.2.2.20 The carborne ATP equipment is organized to perform the four functions. Receive and decode the speed limit and door control commands. Measure train speed and compare it to the speed limit. Control the door operations and check door position. Apply Full Service Braking in the event of overspeed or system failures which affect safety.

1.2.2.21 The carborne ATP System has the capacity to receive and decode 12 commands from the front of the train and two commands from the back of the train. The commands are: 15 mph, 22 mph, 28 mph, 35 mph, 40 mph, 45 mph, 50 mph, 55 mph, 65 mph, 75 mph, open right doors and open left doors. Absence of an ATP command is interpreted by the equipment to mean "STOP" when operating in the Automatic mode and "STOP AND PROCEED at 15 MPH" when operating in the Manual mode.

1.2.2.22 ATP command reception is accomplished through two coils mounted on the cab end of each car. The coils are rigidly mounted to the car body with the center of the coils 31.25 inches ahead of the centerline of the lead axle. The bottoms of the coils are nominally 8 inches above the top of rail and the lateral distance between coil center lines is 44 inches.

1.2.2.23 Two receivers are provided on each "A" car. One receiver, hereafter referred to as the front-end receiver, receives and demodulates the ATP signals presented to the front of the train while the second receiver, hereafter referred to as the back-end receiver, receives and demodulates the ATP signals presented to the back of the train. The code output of the front-end receiver is monitored by six code-rate detectors, each of which drives a vital relay when its associated code rate is present. The worst case time between removal of a speed command to drop away of the associated code rate and carrier relays is 2 seconds. The normal time required to change speed commands is between 0.5 and 1.0 seconds.

1.2.2.24 The contacts of the six code-rate relays and the two carrier relays driven from the front-end receiver are fanned to decode the command. The decoding fans are such that the most restrictive command has priority. The command decoding fans output to the speed selection circuits for overspeed protection, speed selection circuits for automatic speed regulation, automatic door control, limiting speed indicators on the control consoles and brake interface.

1.2.2.25 Overspeed protection equipment that compares the speed selected by the command decoding fan, in connection with the automatic-manual circuits, to the actual train speed is provided. Actual train speed is derived from a speed sensor monitoring the rotation of a gear in a gear unit. Wheel wear compensation is provided in discrete steps to correct for variations in wheel diameter on the axle monitored by the ATP speed sensor. The overspeed protection unit energizes a vital relay to indicate that the actual train speed is less than the limiting speed and that the unit is operating properly. In the event of a failure, or if the actual train speed exceeds the speed limit, this vital relay becomes de-energized.

1.2.2.26 When the train is in automatic operation, an overspeed condition detected by the Overspeed Protection System results in the removal of all calls for positive tractive effort and initiates a Full Service Brake application. The Full Service Brake application is enforced until the overspeed condition no longer exists.

1.2.2.27 When the train is in the manual-operation-with-overspeed-protection mode, an overspeed condition detected by the Overspeed Protection System results in the removal of all calls for positive tractive effort and initiates a Full Service Brake application. An overspeed warning in the cab is also sounded and persists until the attendant places the master controller into the Full Service

Brake position. The Full Service Brake application is enforced until the attendant has placed the master controller in the Full Service Brake position and the overspeed condition no longer exists. When the train is in the manual-operation-with-ATP-cutout mode, no action shall be taken by the ATC System as a result of an overspeed condition.

1.2.2.28 The Overspeed Protection System also includes zero speed detection circuitry. The train is indicated as being at zero speed when the speed is being detected, in a fail-safe manner, to be below 1 mph.

1.2.2.29 Signals received by the front-end receiver of the train determine on which side of the train the doors are to open, and also prove that the frontmost side door of the train is within the platform limits. The signal received by the back-end receiver of the train proves that the rearmost side door of the train is within the platform limits.

1.2.2.30 The output of the back-end receiver is decoded to detect the presence of code rate 1 (3.0 Hz). The presence of this code rate causes energy to be applied to trainline wires at the back of the train. Door control circuits in the controlling "A" car monitor these trainline wires to provide back-end status.

1.2.2.31 A cycle check system is provided in the passenger stations, via the Train-to-Wayside Communications (TWC) System, which is used to confirm that the train is located in a passenger station before doors can be operated.

1.2.2.32 The Automatic Train Supervision (ATS) System is that part of the ATC system which provides centralized monitoring and supervision capabilities and certain automatic ATC supervision facilities at wayside. The ATS system consists of five major components. A computer system and central control consoles located at the Operations Control Center (OCC) in the Jackson Graham Building. A Data Transmission System (DTS) linking the equipment at the OCC with that in the TCRs. Remote Terminal Units (RTUs) located at the wayside Train Control Rooms (TCRs) (The RTUs are hard-wired remote control devices dedicated to the monitoring and supervision of certain wayside ATC functions and devices as well as the electrical and support facilities at the location). A Train-To-Wayside Communications (TWC) system to provide a two-way link between the TCR equipment and trains at stations. An Automatic Car Identification (ACI) system. This system has optical scanners located at certain points next to the tracks. These scanners read the car numbers from a train as it passes the scanner. The car identification is reported to the central computer, which can then determine the car mileage. This information can be used for maintenance purposes and analysis of operations.

1.2.2.33 The central control facility contains a control computer, a hot backup computer, and a computer for software development, which also serves as the ultimate backup computer. The control computer receives and transmits messages between the operations control center and station locations via the DTS. It communicates with the central control operator by providing displays on a large-scale display and video monitors (CRTs), and by accepting operator input from console trackballs and keyboards. The control computer performs schedule adjustments by changing dwell times and interstation run times, both of which are sent to the station RTUs via the DTS. The METRO system can operate as a stand-alone entity without the computer complex at the OCC. However, without the capabilities provided by the ATS software in the central control computer, the display system, and the DTS, the job of monitoring and controlling the METRO operations, especially to maintain schedules, would be more difficult. This is especially true when an abnormal condition (e.g., a malfunctioning train) is encountered. The general functions provided to aid the central control operators are:

a. Display System
   1) Train System Displays
   2) Train and Interlocking Detail Displays
   3) Train Information Displays
   4) Electrical System Displays
   5) Train and Electrical System Alarm Display
   6) Geographic Displays
b. Monitoring Traffic Regulation
   1) Schedule Control
   2) Schedule Adjustment Strategies
   3) Schedule linkage of train put-ins
c. Supervisory Capability
   1) Train Control requests to wayside ATP system
   2) Interlocking requests to wayside ATP system

1.2.2.34 The software for the central computer has been designed in a building block approach and provides the primary functions of Traffic Regulation and Control and Display.

1.2.2.35 All trains in the METRO system under central computer supervision enter revenue service, run, and terminate revenue service according to times provided by predetermined train schedules. These train schedules are the basis for Traffic Regulation control. A train schedule is defined as a set of arrival and departure times at successive locations which completely dictates a train's intended movement from entry into revenue service until lay up. A train schedule defines, among other things, the scheduled arrival time and the scheduled dwell time at every station traversed by a given train. A unique schedule is defined for each train that is in revenue service or is about to enter revenue service. The system schedules are selected by the central control operators at the start of revenue service on a particular day.

1.2.2.36 Traffic Regulation automatically maintains the scheduled headway between all of the trains operating in the territory and regulates train movements for time schedule adherence, proper merging of trains at rail line junction points, and optimum utilization of terminal locations. This is achieved by control of both station dwell time, and train performance (speed) and acceleration levels that govern the interstation running time.

1.2.2.37 The four main components of the Traffic Regulation software are Put-in Processing, the Line Algorithm, the Terminal Algorithm, and Strategy Selection. Also, statistics of the actual performance of trains are gathered for off-line analysis.

1.2.2.38 The Put-in Processing software initiates train entry into revenue service either from a storage point, such as a yard or a pocket track, or from a terminal station after a train reversal. The primary function of the Put-in Processing software is to construct a schedule for the next terminal-to-terminal run of the train so that the Terminal Algorithm and the Line Algorithm can control it. Another function performed is the lighting of warning lamps at yards prior to the scheduled dispatch of a train so that the yard personnel can prepare a train for revenue service.

1.2.2.39 The primary function of the Line Algorithm is to attenuate delays due to minor line disturbances as quickly as possible and prior to the arrival of trains in areas where the probability of such delays is high. Line disturbances are events or conditions that cause a train to be early or late with respect to its schedule. Such events cause the Line Algorithm to affect the dwell time of a train at a station and the performance of a train departing from a station. The Line Algorithm minimizes or eliminates the effects of delays by adjusting the dwell and performance level of a train such that the departure schedule error at a station and the arrival schedule error at the next station are both minimized

1.2.2.40 There are four "Performance Levels" for train operation. Performance Level 1 (PL1) (MAXIMUM) requests the train to run at the maximum safe interstation speed, resulting in the minimum safe interstation run time. The normal schedule for a train is based on PL2 (NORMAL), which is approximately 10 percent slower than PL1. This gives traffic regulation a catch-up capability by allowing it to request PL1 to reduce a train's lateness. PL3 (REDUCED) and PL4 (RETARDED) are approximately 10 percent and 20 percent slower than PL2 and are used when trains are ahead of schedule. The Performance Levels are implemented by imposing applicable maximum ATS speed limits on trains between successive station pairs.

1.2.2.41 Each of the four performance levels may be combined with a request for either full or half acceleration, thus providing eight different interstation run times. For each station platform the program can select either a normal dwell time or another value which lies within the range of minimum and maximum dwell times for that platform. Dwell times available for some platforms can be varied with the time of day.

1.2.2.42 A special case handled by a part of Traffic Regulation called the Terminal Algorithm is used to avoid conflicts between trains at terminals having a crossover interlocking located between the terminal station and the penultimate station. Since these interlockings are used to reverse trains, conflicts in the use of the interlockings can be generated by trains arriving at and departing from a terminal station at close headway. A route conflict exists whenever two trains attempt to traverse conflicting routes through an interlocking at the same time.

1.2.2.43 The central control operators have the capability of providing corrective strategies through the Strategy Selection program whenever required. The control philosophy employed here is that the operator is the best judge of what corrective action is most suitable in any given situation and the computer is most useful as a device to display the options available and to implement the selected option.

1.2.2.44 The Strategy Selection programs include Replace Train, Delete Train, Add Train, Eliminate Gap, Create Gap, Offset Schedule, Tilt Schedule and Skip Stop. All act to either modify or maintain the existing schedule.

1.2.2.45 The Control and Display software drives the displays and alarm printers and responds to central control operator inputs through the console trackballs and keyboards. The Control and Display software responds to field changes or when requested by an operator input to update train displays. It examines the data returned from the field and marked as changed by the Data Base Processor software. It then updates displays and alarm messages for the central operator as required.

1.2.2.46 The Control and Display software provides the processing of all operator inputs and coordinates execution of the software required by those inputs. These commands allow the central control operators to manually supervise system operation and to request specific displays.

1.2.2.47 The Control and Display software drives the displays and alarm printers and responds to central control operator inputs through the console trackballs and keyboards. The Control and Display software responds to field changes or when requested by an operator input to update train displays. It examines the data returned from the field and marked as changed by the Data Base Processor software. It then updates displays and alarm messages for the central operator as required.

1.2.2.48 The Control and Display software provides the processing of all operator inputs and coordinates execution of the software required by those inputs. These commands allow the central control operators to manually supervise system operation and to request specific displays.

1.2.2.49 The system hardware is used to perform the required Automatic Train Supervision functions and backup functions. The individual components are integrated to provide the means by which the various software components perform their functions.

1.2.2.50 Three interconnected computers comprise this subsystem. Each computer consists of a central processor with byte addressing, floating point and memory protection instructions, a priority interrupt system, and a power monitoring circuit. The computer systems are networked to each other and to the peripheral devices through a dual Ethernet network.

1.2.2.51 To handle the specialized data transmission, the central computers are connected to two Front End Processors (FEPs) which are connected to a bank of modems. The modems are connected through the DTS to the various field devices and permit the transfer of data to and from the central control computer. The FEPs receive the raw data from the field and forward change information to the central processors.

1.2.2.52 The Control and Display subsystem, used by the central control operators in controlling the system, has as its main functions; the presentation of system status, operational data and alarms to the central operator, and; the execution of system commands from the console trackball and keyboard. Video monitors (CRTs) provide the display facility with: 1) "Closeup" views of the interlockings; 2) System alarms (Train and E&S Alarms); 3) Performance statistics (Train Information); 4) Electrification system (Traction Power) overview and; 5) State of mechanical support equipment at a station selected by the operator (Support Station).

1.2.2.53 In the event that a CRT malfunctions, the central control operators have the capability of reconfiguring the displays so that a desired display can be moved to a working CRT. A Large Scale Display System provides an overview display of the METRO System and can also be used to display any of the System's local or special displays.

1.2.2.54 All alarm conditions on the METRO System, whether the result of train control indications, calculations, traction power and support system indications or computer indications, are displayed in tabular form on the appropriate alarm display and can be output to a printer. Alarms are also displayed in the alarm area (bottom three lines) of the CRT screen. Each message is accompanied by an audible alarm. The alarm area contains up to three of the most current unacknowledged alarm messages. There is an indication if there are more than three currently unacknowledged alarms.

1.2.2.55 There are five elements of ATS located on the wayside, primarily in the Train Control Rooms at passenger stations.

1.2.2.55.1 The door and dwell control modules provide the local hardware to implement the controls generated by central control or automatically by normal train operations. This hardware is configured to provide a backup means of door and dwell control in the event that control from central is interrupted. The configuration is such that the local backup provisions are exercised on each train movement to make failures self-evident. The sequence of operation is as follows:

1.2.2.55.1.1 When an arriving train completes its station stop a TRAIN BERTHED signal is transmitted to the station via the TWC system. Receipt of this signal causes the speed commands to be removed from the platform block and the block downstream of the platform, the door open commands to be applied at both ends of the platform after a 2 second delay, and energy to be applied to the local dwell timer. The TRAIN BERTHED signal is also transmitted to central control via the DTS.

1.2.2.55.1.2 Upon expiration of the preset time of the dwell timer, the door open commands are removed and speed commands restored unless override controls are received from central control.

1.2.2.55.1.3 The dwell can be terminated prior to the expiration of the preset time by receipt of the TERMINATE DWELL control from central control or by manually closing the train doors.

1.2.2.55.1.4 The dwell can be extended beyond the preset time with the doors held open by receipt of the HOLD WITH DOORS OPEN control from central control.

1.2.2.55.1.5 The dwell can be extended beyond the preset time with the doors closed by receipt of the HOLD WITH DOORS CLOSED control from central control. In this case the door open commands are removed but the speed commands are not restored until the HOLD WITH DOORS CLOSED control is no longer received.

1.2.2.55.1.6 At selected stations a local train dispatching system was provided for schedule control in the event of failure of the central control function. At these locations the expiration of the preset dwell time would not terminate the dwell unless it was also time for the train to be dispatched from that station. (The automatic dispatching machines originally installed as parts of this system are no longer being used.)

1.2.2.55.2 Train-to-Wayside Communications (TWC) system provides the communications link for the ATS functions between revenue trains and the wayside. The TWC System is a continuous-scanning, time-division multiplex transmission system in which communications transmitted to wayside and received from wayside are time-shared. The carborne TWC System is inductively coupled to the wayside TWC System via coils on the cars. At wayside receiver locations other than flyby locations, the area of effective two-way communications is at least 600 feet long. Two message formats are transmitted by the train and received by the wayside, short message format (15 bits) and long message format (51 bits). The prefix bit configuration for the short message mode is MARK-SPACE-MARK. The prefix bit configuration for the long message mode is MARK-MARK-MARK. The suffix bit configuration for both long and short message modes is MARK-MARK-MARK. The message structure is a non-synchronous, return-to-zero, serial code at a bit rate of 100 bps. There is a 100-millisecond pause between successive message transmissions from the trains. The message starts 60 ms after the transmitter is keyed. The TWC carrier frequency is 9800 Hz. A frequency of 9950 Hz is interpreted as a "MARK." A frequency of 9650 Hz is interpreted as a "SPACE." Parity is "ODD." The existing impedance bonds that are tuned to transmit and receive the TWC signals exhibit impedance of approximately 1.0 ohms at 9800 Hz. With this impedance, the TWC system will work reliably with a receiving bond current of .016A rms to 0.3A rms. The transmit rail current produced by the bond is approximately 1.5A rms with a train adjacent to the bond. Input to the TWC receiver is 400-mV p-p.

Two message formats are transmitted to the trains depending upon the location of the transmitter, short message format (11 bits) and long message format (51 bits). The long messages are transmitted to trains in response to a received message from the train at all locations other than flyby locations. Short messages are transmitted to trains in response to a received message at flyby transmitter locations.

1.2.2.55.3 The Automatic Car Identification (ACI) system provides a means of identifying train consists by car serial number. This data is transmitted to central control via a low speed data channel and presented to the central computer where it is associated with the appropriate train I.D. data. The system is an optical scanning system which recognizes color strip labels affixed to the cars. The labels are a short version (7 digits) of the former standard AAR label. The scanners are located in the downtown area such that six scanners are sufficient to read the consist of all revenue service train movements.

1.2.2.55.4 The performance level translator converts the two-bit performance level control received from Central Control into a four-bit binary code, which identifies the ATS speed limit required to achieve the desired performance level. The ATS speed limit code produced by the performance level translator for a given performance level code input is determined by the wiring of a programming plug. The correlation between performance level and ATS speed limit (programming plug wiring) for a given station-to-station run is based on computer simulations of station-to-station runs with each of the ATS speed limits. The performance level translator is a part of the TWC transmitter module. The ATS speed limit code produced by the translator is transmitted to the train via the TWC system. The trains interpret the ATS speed limit code as follows:

ATS CODE	SPEED LIMIT	ATS CODE	SPEED LIMIT
0000	79	1000	44
0001	79	1001	49
0010	14	1010	54
0011	19	1011	59
0100	24	1100	64
0101	29	1101	69
0110	34	1110	74
0111	39	1111	79

1.2.2.55.5 The wayside portion of the data transmission system (DTS) consists of remote terminal units(RTUs) and their associated interface hardware and wiring. Earlier portions of the existing system use model 9600 RTUs manufactured by TRW Controls. These RTUs operate at a bit rate of 1200 or 2400 baud depending on the total number of controls and indications for which the RTU is equipped. The maximum capacity of these RTUs is 836 controls and 892 indications. The model 9600 RTUs are interfaced to a voice grade channel between the RTU and central control via model P1224 modems manufactured by TRW Controls. Newer portions of the existing system use OUTPOST Model 409 RTUs manufactured by Network Management Technologies, Inc., Sugar Land, Texas.

1.2.2.56 The Automatic Train Operation (ATO) System is that part of the ATC System which provides automatic train stopping and starting at passenger station platforms and provides speed control compensation for varying conditions of grade and curvature. The wayside portion of the ATO system consists of the markers used to identify grade and curve information and the station stopping markers which provide the distance-to-centerline information as well as the type of stop (long, short, center, or skip) information.

1.2.2.57 The markers are tuned circuits, the inductance of which is an air core coil with an inside diameter of approximately 11 inches. The coil is the coupling element to the carborne equipment and is located between the running rails with its axis vertical. The top edge of the coil is between 1/4 and 3/4 inches below the top of rail. The relationship between the coil center and the track centerline is as follows:

RADIUS OF CURVE	OFFSET [1] FROM CENTERLINE OF TRACK
Greater than 8500'	0"
8500' - 2900'	1"
2899' - 1750'	2"
1749' - 1250'	3"
1249' - 975'	4"
974' - 800'	5"
799' - 700'	6"
Less than 700'	7"

(1) Offset from centerline of track is toward the outside of the curve. See the Technical Appendix, "Marker Coil Offset vs. Curve Radius."

1.2.2.58 Each marker location except the 160 ft. marker consists of two independent tuned circuit members. This configuration is used to provide for double direction running and to provide the required amount of data with fewer frequencies. The carborne portion of the ATO System consists of marker reception and decoding equipment, station stop control equipment, and speed regulation equipment.

1.2.2.59 The marker reception and decoding equipment responds to the wayside markers, validates the data and passes the valid data to the speed regulation and station stopping equipment. The station stopping equipment generates a velocity vs. distance profile upon receipt of an initiating marker. The slope of the stopping profile is determined by the grade and curve data also received via the marker system. The stopping point within the station (point at which profile velocity reaches zero) is determined by the type of stop data received via the marker system and the train length determined by the carborne train length measuring circuits. Intermediate station stopping markers are used to correct the velocity vs. distance profile to compensate for differing wheel diameters and the effects of slip and slide.

1.2.2.60 The speed regulator measures actual train speed and controls the power and braking to cause the actual speed to approximate the desired speed. The desired speed is defined as the lesser of ATP Speed Command, ATS Speed Limit, or Station Stopping Profile Velocity. In normal running the speed regulator will cause the actual speed to be equal to the desired speed +0 mph, -4 mph. The actual train speed and the distance base for the station stopping profile are derived from axle rotation. Manually adjusted wheel wear compensation is provided to minimize the errors due to changes in wheel diameter over the life of the wheels.

1.2.3 Communications (excluding IT)

CENI-COMM is the department at WMATA responsible for the design, build, operation, and maintenance of communication related systems. Communication related systems at WMATA include the Fire Alarm system; the Access Control system; the Closed Circuit TV (CCTV) systems; the Public Address (PA) system; the Call-For-Aid system; the Radio system (both WMATA and Public Safety of local jurisdiction); the Chemical Biological Detection system; the KIOSK systems; as well as various other low voltage systems.

1.2.3.1 Fire Alarm System

The Fire Alarm system consists of Fire Detection sensors, Fire Alarm devices, and local Fire Control panels installed at all WMATA facilities including rail stations, rail yards, bus garages, and other miscellaneous facilities such as CTF, Stone Straw, Material Supply facility etc. Additionally, the Fire Alarm system is monitored remotely at JGB, CTF, and 3421 Pennsy Drive.

WMATA has standardized on the Edwards EST3 Fire Alarm system. The Fire Alarm system interfaces with several other systems such as the Fare Gates, the Elevators/Escalators, and the HVAC system.

1.2.3.2 Access Control System

The Access Control system consists of controllers, card readers, intrusion detection sensors, request-to-exit sensors, door strikes and other devices required to secure WMATA facilities from unauthorized access and report in a timely fashion when security is breached. WMATA plans to use the WMATA ID badges for Access Control in the future. All access control systems report to the PSIM software running in the SOCC at 341 Pennsy Drive.

WMATA has standardized on the ProWatch Access Control system with Oberthur card readers. There is a huge installed base of Edwards EST3 Access Controllers at WMATA.

1.2.3.3 Closed Circuit TV System

The CCTV video surveillance system consists of cameras, recording devices, cabling (both fiber optic and copper), network switches and display systems required for WMATA to conduct real time video surveillance as well as conduct post incident investigations. All camera systems report to the PSIM software running in the SOCC at 341 Pennsy Drive.

WMATA has standardized on Axis IP cameras, Verint Video management Software, Pivot3 recorders, COMNET switches, and Dell Viewing stations.

1.2.3.4 Public Address System

The PA system consists of amplifiers, speakers, microphones, priority mixers, an IP connection to OCC, and other devices required to produce high fidelity announcements to passengers and employees at WMATA rail facilities. The PA system is considered a part of the Fire Alarm system. A head end for the rail system PA system exists at both JGB and CTF.

WMATA has not standardized on a PA system. There is a large variety of PA systems with respect to manufacture, age, and functionality installed at WMATA.

1.2.3.5 Call-for-Aid System

The Call-for-Aid system consists of emergency call boxes, controllers, status indicators and other devices required to provide emergency communications between the traveling public and WMATA. Call-for-Aid stations are installed at platforms, AORA and elevators.

WMATA has standardized on the Commend platform to provide Call-for-Aid functionality.

1.2.3.6 Radio System

The Radio system consists of above ground infrastructure, below ground infrastructure, and subscriber units. The below ground infrastructure includes the various Public Safety Radio systems (PSRS) of local jurisdictions. In addition to handheld subscribers, there are subscriber units installed on busses, rail vehicles, maintenance vehicles, and police vehicles. WMATA's current radio system, the Comprehensive Radio Communication System (CRCS) is a Motorola digital trunked simulcast system which operates in the 490 MHz frequency range. The various PSRS systems (installed in the underground) for local jurisdictions, generally operates in the 800 MHz frequency range.

The Comprehensive Radio Communication System (CRCS) is a Digital Trunked Simulcast radio system by Motorola that operates above ground from 10 towers and below ground over a Distributed Antenna System. The Distributed Antenna System is shared by both WMATA radio and local public safety radio systems. WMATA is transitioning to a new 700 MHz radio system.

1.2.3.7 Chemical Biological Detection System

The Chemical Biological Detection system consists of the chemical sensors and processing units required to detect and report on chemical agents released within the WMATA underground system. The name for this system is PROTECT. A head end for the PROTECT system exists at both JGB and CTF.

WMATA has not standardized on a single CBEMIS sensor. There is a large variety of CBEMIS systems with respect to manufacture, age, and functionality installed at WMATA.

1.2.3.8 Kiosk System

The Kiosk system consists of the enclosure and embedded electronics used by station managers to monitor and operate each rail station. Embedded electronics include the panels to monitor operation of the elevators and escalators, the Annunciator panels for the Fire and Intrusion system, the display system for the CCTV system, and other systems required by the station manager.

1.2.3.9 Various Low Voltage Systems

In addition to the above mentioned systems, the Communication section is responsible for various low voltage systems that occur within the authority on a limited basis. Examples include LNG gas detection system installed at bus garages that employ LNG servicing and Veeder Root tank level monitoring systems.

1.2.3.10 System Integration

The system integration effort consists of equipment, cabling, and monitoring software required for integrating the operation of WMATA bus and rail operations as well as supporting functions. As such, the communication section must be familiar with other disciplines such as traction power, train control, electrical/mechanical, and fare collection. A thorough understanding of fiber optics and network technology is required to ensure integration between systems.

1.2.4 Trackwork

1.2.4.1 There are currently four (4) rail support systems within the WMATA system. Ballasted track on wooden ties, direct fixation track, special trackwork and embedded track. A typical track section incorporates 115RE rail. Where necessary, WMATA has optimized current WMATA standard practices to require 132RE restraining rails to be incorporated to guard No. 6 and No. 8 turnouts and critical points along mainline, yard and secondary tracks to protect against misdirected rail wheel movements.

1.2.4.2 Turnouts were designed and fabricated to maximize functionality and provide precision installation and attachment to continuously welded rail. Fully guarded turnouts are provided where necessary, and the minimum size within the yard is No. 6. All rail is fully heat treated within the WMATA system. Rail joints within turnouts comply with standard turnout details and dimensioning. All rails within turnouts fasten to the tie plates with type E2056 left-handed Pandrol spring clips. Tie lengths are provided as required by the turnout geometry standard details.

1.2.4.3 Main shop floors of service and inspection buildings are a complex concrete structure with dropbeams and include necessary blockouts and attachments that support an inventory of industrial equipment, embedded rail and high shop live loads of 250 pounds per square foot.

1.2.4.4 WMATA has revised its standard trackwork designs in Design Release 9 in October 2007. These revisions include changes to the turnout design that improves ride quality and reduces maintenance costs.

1.2.4.5 WMATA has operated its Metrorail system for approximately 30 years. As an introduction to the trackwork, one approach is to describe the original trackwork at WMATA, some of which is still in service, and then show the trackwork construction from the latest WMATA contracts.

1.2.4.6 Initially, Metrorail trackwork design was heavily influenced by freight railroad trackwork. Unlike parallel designs at BART (San Francisco), early WMATA ballasted trackwork in the mid to late 1970's, including AREMA type geometry turnouts, is close to what you would have seen on a railroad of that period. Direct fixation (concrete slab) trackwork was also relatively simple, consisting of a concrete deck with anchor studs, a relatively thin (1") concrete leveling pad, and early versions of direct fixation fasteners.

1.2.4.7 As Metrorail expanded in both length and passenger volume through the 1980's, its track began to experience increased wear and tear. Some of this deterioration could be attributed to early design flaws; e.g., premature failure of neoprene base pads in the original Metrorail "floating slab" trackwork, and other track maintenance problems became apparent with the less forgiving truck/wheel combinations on successive vehicle fleet series.

1.2.4.8 Although concrete ties are included in the prior WMATA Design Criteria and are proposed for future segments of Metrorail, WMATA ballasted track is currently a wood tie system. One factor favoring this is that Metrorail has a dedicated right-of-way, and extra corrosion control measures have been limited to relatively heavy coatings and cathodic protection for metallic utility lines located within the property limits.

1.2.4.9 In any case, Metrorail trackwork has developed over the past 30 years to handle the ever increasing level of traffic on the system. This evolution is summarized in the outlines and photographs that follow below, organized by major track assemblies.

1.2.4.10 Rail - Original/Early Construction

1.2.4.10.1 Running Rail: 115 RE Rail Section, Control Cooled (260 BHN) and Fully Heat Treated (320 BHN) Rail, some Alloy Rail, Mixed Bolted and CWR

1.2.4.10.2 Restraining Rail: Horizontally Mounted 132 RE Rail Section, Web Bolted to Plate Mounted Brackets

1.2.4.11 Rail - Current Construction

1.2.4.11.1 Running Rail: 115 RE Rail Section, Control Cooled (308 BHN) and Head Hardened (360 BHN) Rail, CWR

1.2.4.11.2 Restraining Rail: 115 RE Rail Section, Vertically Mounted on Stepped Baseplate, Boltless Braces, Adjustable Split Spacer Blocks

1.2.4.12 Ballasted Track - Original/Early Construction

1.2.4.12.1 Wood Ties, AREMA Rolled Plates, Cut Spikes, Drive Anchors, Box Anchoring Every Other Tie

1.2.4.13 Ballasted Track - Current Construction

1.2.4.13.1 Wood Ties, Pandrol Rolled Plates, Screw Anchor Spikes, Pandrol left hand 'e' Clips

1.2.4.14 Photos - Original/Early Construction

Ballasted Track, Cheverly Station

1.2.4.15 Current Construction

Ballaste d Track,
Branch Avenue Station

1.2.4.16 Direct Fixation Track - Original/Early Construction

1.2.4.16.1 Drill & Grout Installation: 3/4" to 1" Thick Concrete Grout Pads, Anchor Studs, Landis/Hixson DFF (Zero Cant) with Rigid Clips

Hixon Fastener - Plan View

Landis Fastener - Plan View

1.2.4.16.2 Noise & Vibration Control: Floating Slab, Neoprene Pads

1.2.4.17 Direct Fixation Track - 1990 Construction

1.2.4.17.1 Drill & Grout Installation: 3/4" to 1" Thick Epoxy Concrete Grout Pads, Anchor Bolts, Lord DFF (Zero Cant) with Pandrol LH 'e' Clips

L ord Fastener-Oblique View

1.2.4.17.2 Noise & Vibration Control: Floating Slab, Natural Rubber Pads

1.2.4.18 Direct Fixation Track - Current Construction

1.2.4.18.1 Drill & Grout Installation: 1" to 1 1/4" Thick Concrete Grout Pads, Resin Overlay, Anchor Bolts, Lord DFF with Pandrol LH ‘e’ Clips

1.2.4.18.2 Top-Down Plinth Install: Plinth Concrete (No Grout Pad), Anchor Bolts, Foster F-20 DFF (Zero Cant), Pandrol LH ‘e’ Clips

F20 Fastener - Section

1.2.4.18.3 Noise & Vibration Control: Cologne Eggs

1.2.4.19 Third Rail - Original/Early Construction

1 **1.2.4.19.1** 150 lb Rail, Porcelain Insulators at All Locations

1.2.4.20 Third Rail - Current Construction

1.2.4.20.1 Composite Steel-Aluminum 80 lb. Rail, Fiberglass Insulators at all locations (although porcelain insulators still exist in the underground portions of the WMATA system; however are no longer being installed or procured for maintenance replacement)

1.2.4.21 Turnouts - Original/Early Construction

1.2.4.21.1 Turnout Types: No. 4 Equilateral, No. 6 AREMA Geometry (13'-0" Curved Point), No. 6 Equilateral, No. 8 AREMA Geometry (16'-6" Straight Point), No. 10 AREMA Geometry (Modified), No. 15 AREMA Geometry (26'-0" Curved Point)

Cheverly Station Interlocking

1.2.4.22 Turnouts - Current Construction

1.2.4.22.1 Turnout Types: Guarded No. 6, Guarded No. 6 Equilateral, Guarded No. 8 Constant Radius (Main Line), No. 8 Straight Point (Yards), No. 10 Constant Radius, No. 15 Constant Radius

National Airport Station Interlocking

1.2.4.23 Track Gauge:

Horizontal Track Alignment	Main Tracks	Yard & Secondary Tracks
Tangent Track	4' - 8 1/4"	4' - 8 ½"
Radius > 1425'	4' - 8 1/4"	4' - 8 ½"
Radius > 350 ≤ 1425'	4' - 8 ½"	4' - 8 ½"
Radius ≤ 350'	Not Applicable	4' - 9"
Radius ≤ 350'	Not Applicable	4' - 9 1/4"

1.2.4.23.1 WMATA had developed switch guarding and geometric turnout changes for the various turnouts within the system to introduce a constant radius turnout geometry and low switch point entry angles that were incorporated in the TSSM procurements. As the 5000 and 6000 series WMATA vehicles have come on line, it has became increasingly important to include these changes in new Metrorail turnouts and current design criteria.

1.2.4.23.2 Where they exist, differences between the "tangential" geometry turnout developed under WMATA capital construction contracts and the Department of Track Structures and System Maintenance (TSSM) procurement versions are relatively small, primarily involving minor curve radius differences and items such as turnout switch block configuration. One exception is the use of the H-series insulated base plates for the Largo Extension turnouts, but problems in maintaining turnout line and anchor bolt stability for these installations have resulted in, at least for the present, their rejection as a design alternative standard for WMATA.

1.2.4.23.3 In general, revisions to the No. 6 guarded equilateral turnout, No. 8 turnout, and No. 8 guarded turnout are relatively minor and deal mostly with component upgrades. The No. 10 and No. 15 turnouts, on the other hand, have been completely reconfigured since initial design conception.

1.2.4.23.4 Consolidation of the Office of Track and Structures and Office of Systems Maintenance (Automatic Train Control) in 2005 has led to enhanced teamwork and communication channels in further updates for trackwork design drawings. The reorganization has allowed further engineering designed to accommodate both disciplines. There have been minor revisions in switch tie spacing to not only accommodate switch point protectors in No. 6 guarded turnouts, but also to allow for proper placement and drilling of the switch heater rod(s). There have also been minor revisions to the rail gap for the 1/4 inch insulated one piece end post for the double rail insulated joints.

1.2.4.23.5 The standard plastic contact rail insulator has also been replaced with a more durable fiberglass insulator for direct fixation trackage. The cross section of the top housing of fiberglass insulator was broadened to act as an “umbrella” over anchorage hardware. The prior anchorage hardware design (plastic insulators) in the underground tracks required more maintenance to prevent failure from water intrusion falling onto the hardware.

1.2.4.24 Drilling patterns for insulated gauge plates (plate insulator) for No. 8 guarded turnouts have also been revised to accommodate the Systems Maintenance discipline.

1.2.4.24.1 Insulator fiber washers for the special plate anchorage assemblies (direct fixation trackage) have been re-designed as a one piece sleeve and washer to increase resilience of the anchorage assembly.

1.2.4.24.2 There has also been design modifications to increase the strength of the ductile iron chairs for the No. 8 guarded ballasted turnouts.

1.2.4.25 Historical Summary, Track Modifications:

1.2.4.25.1 By the early 1980's, it became apparent that the original equilateral turnouts at National Airport were inadequate for its use as operational turnback. The No. 4 Equilateral at the Inbound (IB) end of the platform was replaced with a guarded No. 6 Equilateral turnout in 1982 with the intent of increasing the 228 feet radius of the original No. 4 Equilateral turnout closure curve for the turnback operation noted above.

1.2.4.25.2 However, the switch point was retained in its existing location, necessitating a shortening of the typical No. 6 Equilateral turnout by 8 feet and a significant short curve immediately beyond the frog heel to keep the track on the underlying box structure. Although the modifications increased the curve radii, the improvements were modest at best. The turnout closure curve was a compound curve with minimum 353 feet radius, and the short curve beyond the frog heel had an approximate radius of 284 feet.

1.2.4.25.3 Derailments at Brentwood Yard and the Farragut North pocket track in 1993, attributed to the increased minimum track radius requirements of the then-new Breda cars, necessitated a change to replacement of all No. 4 Equilateral turnouts with guarded No. 6 Equilateral turnouts. Revised locations ultimately included Farragut North, D/G Junction, Grosvenor, and National Airport. As National Airport was no longer a turnback location by that time, turnout replacement was performed after the other more critical locations.

1.2.4.25.4 In 1996, the No. 6 Equilateral turnout on the Inbound (IB) side of the National Airport platform was replaced. At the same time, the No. 4 Equilateral turnout on the Outbound (OB) side of the platform was changed to a guarded No. 6 Equilateral turnout as well. The four No. 8 turnouts on the IB and OB Tracks were retained in their original locations. Although there were now guarded No. 6 Equilateral turnouts on both ends of National Airport Center Track, there were differences in the installation of these two turnouts.

1.2.4.25.5 The No. 6 Equilateral turnout at the OB side of National Airport was installed with its switch point relocated approximately 22 feet closer to the end of platform. This location permitted the turnout to remain on the existing underlying box structure and the track tangent extension from the frog heel led directly into the PI of the existing connecting track, minimizing track relocation on the structure deck. Turnout closure curve radius (guarded) was 566 feet, and the unguarded curves between the turnouts had 462 feet radii. The relocation of the turnout switch required a reconstruction of the structure deck to accommodate the switch rods and shaving the center platform end (granite edges) by approximately 1/4 inch.

1.2.4.25.6 On the IB side of National Airport, a similar configuration would have required not only new concrete deck slots for the switch rods and platform modifications, but also additional deck slots for a relocated derail. The 1996 retrofit work for the guarded No. 6 Equilateral turnout on the IB side of National Airport thus did not relocate the switch. The turnout was shortened by approximately 8 feet as well, This resulted in a guarded turnout with a closure curve radius of around 450 feet, and retention of the 284 feet radius curve (unguarded) behind the frog heel.

1.2.4.25.7 The 2003 derailment at National Airport occurred in the vicinity of the above 284 feet radius curve, and the curves beyond the frog heel of the No. 6 Equilateral turnout were subsequently guarded at that location. Current design criteria requires restraining rails to be installed on all main track (revenue service tracks) with curves of radius less than 800 feet. Additional maintenance directives to manually lubricate all No. 6 and No. 8 turnouts were also implemented, although the current closure of the National Airport Center Track has made that requirement unnecessary. A program to retrofit all non-revenue service tracks below 500 feet radius with restraining rail is also being implemented where possible.

1.2.4.26 Future Extensions:

1.2.4.26.1 Currently, the Metrorail is being extended to provide service to the Tysons Corner area of Virginia, with further extension to Dulles Airport. Phase I to Tysons Corner is expected to be completed in 2011. Phase II to Dulles Airport is expected to be completed in 2015. No stations will be opened until the completion of each phase. This will add another color to the Metrorail system, “Silver Line”. Drilling began in mid-2006. There are other rumors of a Georgetown Metrorail connector, an extension of the Green Line northward to BWI Airport, another line along I-395 or Columbia Pike in Virginia, and the Purple Line, which is a circular line to go along the Capital Beltway, particularly the portion between Bethesda and New Carrollton. An extension from Franconia/Springfield to Ft. Belvoir is also a possibility due to the BRAC realignment which will place thousands of new jobs at Ft. Belvoir by 2012. While there has been much discussion about all of them, none is in any official planning stage.

1.2.5 Traction Power

1.2.5.1 WMATA is a heavy rail transit system. The transit cars shall be propelled by electric traction motors driving steel wheels through appropriate gearing. Electric traction power shall be supplied to the cars by means of a contact rail installed parallel to the running track, upon which one or more collector shoes attached to each car will maintain sliding contact.

1.2.5.2 Both running rails of both inbound and outbound tacks shall be used as negative return conductors for the traction power system, except at crossover locations and in service and inspection yards where only one running rail provides the negative return.

1.2.5.3 The entire conductor system including the contact rail, the running rails, and associated cable connections shall be capable of supporting voltages to the transit cars.

1.2.5.4 Direct current traction power shall be provided by rectifiers with rated voltage output of 700 volts at one hundred percent (100%) load. Maximum voltage output at one percent load at the substation bus shall not exceed 742 volts. Substation regulation shall not exceed six percent (6%) from one percent to one hundred percent of rated transformer/rectifier capacity and shall be approximately linear to four hundred fifty percent.

1.2.5.5 The WMATA Traction Power System is comprised of strategically located substations ranging from 4MW to 9MW capacities. These substations convert an incoming utility line voltage of 34.5kv ((Dominion Virginia Service Area) or 13kv PEPCO Service Area to 700 V DC nominal for rail cars. The power is distributed via steel or aluminum/steel composite 3rd rail and both running rails are used for traction return current. A minimum of two rectifiers transformers units are used in each substation. Initial modular units were sized at 2MW, but this has recently been changed to 3mw. The running rails are crossed bonded at maximum 200feet intervals to permit return current path over both inbound and out bound tracks. Major components in a traction power substation consist of AC switchgear, dry or oil filled rectifier transformers in 2MW to 3MW,2 OR 2MW rectifiers for converting AC power to DC power, DC feeder breaker switchgear for delivering power to the third rail sections, and finally a negative switchboard for the return cable connection. AC and DC cables as well as AC and DC power busses provides electrical interconnection.

1.2.5.6 Tie breaker stations are provided in between two traction power substations, near special track work or crossover and in passenger stations to provide a means to jumper across the acceleration gap in rails . Atypical installation consist of DC breaker switchgear and associated battery and emergency trip panels.

1.3 Description:

The work effort is composed of providing professional and technical services with qualified personnel. The services to be provided will include expertise in the high voltage AC and DC electrical engineering discipline to include the specialized area of traction power. Consistent with Section 5.2.2, designed work must be approved by an engineer registered in the jurisdiction where the work is to be performed.

1.4 Confidential Information:

The GEC-SYS shall not divulge any confidential information which is acquired in the course of performing the work under this contract. In this respect, the estimate of the cost of construction, based upon the approved designs, drawings and specifications thereof, shall constitute the -Authority's estimate and, no information pertaining to such estimate or estimating shall be disclosed by the GEC-SYS, associates or employees, except to the extent permitted by the Contracting Officer.

1.5 Relationship with Railroads. Private and Public Utilities and Agencies:

The GEC-SYS shall thoroughly coordinate with railroads, public and private utility companies, adjacent property owners and public agencies, as required. Initial contact with the affected utility companies, owners and agencies shall be the responsibility of the GEC-SYS.

2 INFORMATION FURNISHED BY THE AUTHORITY:

2.1 General Documents:

The Authority shall furnish the GEC-SYS with documents as guidelines for work to be performed under this contract. These documents present information relative to the work to be performed by the GEC-SYS. It is the responsibility of the GEC-SYS, however, to gather all data necessary for the performance of this contract and to develop complete and final documentation.

3 SCOPE OF SERVICES:

3.1 General:

The GEC-SYS shall provide the professional and technical staff required to perform the task, at the times requested by the Authority, in the work locations designated in the succeeding paragraphs.

The GEC-SYS shall provide one senior professional engineer for each dicisplane (total of 7), approved by the Authority and not subject to change without the Authority's approval, to be assigned full time to work directly with the Authority's Assistant Chief Engineer/Deputy Chief Engineer. The Assistant Chief Engineer/Deputy Chief Engineer will be designated by the Contracting Officer as Contracting Officer Technical Representative (COTR). The individual will supplement the Authority's technical staff. The individual will serve as liaison between the consultancy and the Authority for larger tasks requiring additional resources.

3.2 Technical Direction:

The work will be conducted under the general direction of the Contracting Officer. Specific individuals will be designated by the Contracting Officer as Contracting Officer Technical Representative (COTR) with authority as listed in Article 18 of the Special Provisions and as set forth in appointment letter(s), copy of which will be provided to the GEC-SYS.

During the prosecution of the work, the GEC-SYS shall maintain close liaison with the COTR, who will coordinate the work with the user Department and other offices. The GEC-SYS shall direct all requests, from user, offices and departments of the Authority, to the COTR for appropriate action.

3.3 Tasks to Be Performed:

3.3.1 The GEC-SYS shall provide professional technical services to a wide variety of new design and construction related tasks and maintenance, repair and renovation tasks requiring the full range of traction power services including:

3.3.1.1 Corrosion Control

3.3.1.2 Electrical

3.3.1.3 Train Control

3.3.1.4 Train Control Studies

3.3.1.5 Track Alignment and Plan/Profile Studies

3.3.1.6 Track Design

3.3.1.7 Track Fastener Design

3.3.1.8 Special Trackwork Design

3.3.1.9 Restraining Rail Design

3.3.1.10 Safety and Security

3.3.1.11 Program and Project Management

3.3.1.12 System Integration

3.3.1.13 Final Design and Contract Document Review

3.3.1.14 Project and Program Management Support

3.3.1.15 Engineering Support

3.3.1.16 Update Engineering Standards

3.3.1.17 Preparation and Review of Contract Technical Specifications

3.3.1.18 Preparation of Estimates

3.3.1.19 Staff Augmentation

3.3.1.20 Field Surveys

3.3.1.21 Field Inspections

3.3.1.22 Constructability Reviews

3.3.2 The tasks will be differentiated essentially by urgency. Generally, the tasks can be classified into two categories:

3.3.2.1 Category I -Normal tasks are tasks which comprise the majority of the work effort. They are planned and prosecuted in accordance with established policy.

3.3.2.2 Category II - Emergency tasks requiring immediate response and quick reaction. which require initiation of critical work effort based on oral guidance from the assigned COTR or the respective alternate COTR to be confirmed in writing as time permits. Category II tasks should rarely occur.

3.3.3 Additional Work Efforts: Because of the nature of the work, it may be necessary in unique situations for the GEC-SYS to obtain additional consultant support from specialty firms from time to time.

3.4 Process for Issuing Task:

3.4.1 Tasks will be issued whenever the Authority's needs exceed the resources of the GEC-SYS's onsite representative. Each task shall be initiated by WMATA transmitting a Scope of Service (SOS) to the GEC-SYS and requesting a cost proposal. The SOS will be developed under the direction of the COTR and vetted through the GEC-SYS's onsite representative. This will insure both the Authority and the GEC-SYS have a thorough understanding of the SOS and will avoid delays caused when proposals are based on a SOS that is misunderstood and requires rework.

3.4.2 The GEC-SYS shall provide a cost proposal based upon the transmitted SOS. The GEC-SYS should propose solutions that take into consideration factors such as safety, economics, resources and new technologies that maintain or enhance the existing system's configuration. The GEC-SYS should recommend alternative solutions to the Authority for further discussion and possible implementation. The proposal shall identify the firm (prime or sub or combination thereof) who will perform the work, the labor classifications, the time each individual will spend on the task, rates for each individual, a schedule including identification of deliverables and all applicable interim and final milestones and completion date(s), overhead and profit rates, direct costs, and any other relevant cost information. Proposals shall be submitted within a reasonable two weeks of receipt of request, unless a different response time is indicated in the request.

3.4.3 The Authority will negotiate a fixed price task order if possible. Indefinite quantity with fixed fully loaded billing rates, and cost-plus-fixed-fee method may also be employed.

3.5 Task Deliverables:

3.5.1 Will be defined in the task scope of service.

3.6 Other Tasks:

3.6.1 The GEC-SYS shall participate in other tasks as required such as those listed below:

3.6.1.1 Provide follow-up professional services as required by the Authority during warranty and construction phase.

4 Quality Control Program:

4.1.1 The GEC-SYS shall develop and be responsible for executing a Quality Control (QC) Program for all Professional Services. This program shall require internal reviews and checks by supervisors, and independent QC checks by well qualified technical staff to confirm that acceptable quality is provided. The GEC-SYS shall be responsible for signing and sealing each drawing to attest the accuracy and completeness of its contents, and to show evidence of compliance with applicable jurisdictional codes. A Quality Assurance/Quality Control (QA/QC) plan shall be submitted to the Authority for approval.

4.1.2 A part time Quality Control Manager shall be designated by the GEC-SYS. Professional Engineering registration in the District of Columbia, Maryland and Virginia is required for this position. The designated QC Manager is subject to the approval of the Contracting officer.

5 Additional Requirements:

5.1 General Requirements:

For all categories of professional services, the following items are required:

5.1.1 All services shall be in accordance with the engineering instructions and standards furnished by the Authority.

5.1.2 Professional services shall consider employee and customer safety, life cycle costs, arability of resources, new technologies that maintain or enhance the existing system's configuration and that implementation will be accomplished in an operating system with minimal down time.

5.1.3 The use of critical and strategic materials not otherwise restricted shall be limited to the minimum amounts required consistent with materials policies. Full consideration shall be given to the use of substitute materials.

5.1.4 Specified materials and methods shall comply with the most stringent environmental criteria as defined by Federal Regulations, State of Maryland, Commonwealth of Virginia, and District of Columbia.

5.1.5 All engineering manuals, specifications and other data furnished by the Authority, as designated by the Contracting Officer, shall be returned to the Authority at the completion of the contract.

5.1.6 After submission of the contract plans and specifications and the quantity surveys and cost estimates, the GEC-SYS shall make any corrections thereto as may be necessary.

5.1.7 All final estimates of cost shall be transmitted to the CO, in envelopes marked

"FOR CO EYES ONLY".

5.1.8 All correspondence shall be referenced to the appropriate project number. Matters relating to the contract, change proposals, billings, etc., shall be addressed and sent, in duplicate to the Contracting Officer, and the COTR Correspondence between GEC-SYS and third parties; one copy each to the Contracting Officer and the COTR.

5.2 Specific Requirements:

5.2.1 For specific categories of GEC-SYS work the following items may be required and will be identified when the task order is approved:

5.2.1.1 Representation:

During the term of this agreement, the GEC-SYS shall attend, or be represented at, meetings and conferences with officials of the Authority, governmental agencies or others interested in the work as may be directed by the Contracting Officer. All such meetings and conferences shall be made a matter of record. The GEC-SYS is responsible for preparing a memorandum stating the time and place of the meeting, the names and identification of those present, and a brief description of the matters discussed and the agreements reached. Memoranda shall be prepared immediately and mailed no more than ten days after the meeting, with two copies being sent to the COTR.

5.2.2 Certification:

The GEC-SYS shall furnish the Authority with a statement signed by the Professional Engineer whose signature appears on the contract drawings, certifying that the drawing and specifications conform to WMATA design criteria and standards and the jurisdictional regulations and ordinances. The person signing must be registered in the jurisdiction where the work is to be performed.

5.2.3 Contract drawings and Specifications:

5.2.3.1 Drawing types, format and sequence are described in WMATA's design criteria and WMATA's cad manual.

5.2.4 Project Cost:

5.2.4.1 Project Cost Control:

The GEC-SYS shall share the responsibility as required for design cost control with the Authority. Prior to the time of the project intermediate review submittal (70% completion of design), the GEC-SYS shall use the Authority's budget cost and schedule as guides in the preparation of the design.

5.2.4.2 Quantity Survey:

Quantity surveys shall present separate quantities for each line item as directed by the Contracting Officer. The quantity surveys shall be itemized in units of work, materials and equipment, together with the amounts of the same, in accordance with a breakdown approved by the Contracting Officer. Quantity surveys shall be in sufficient detail to permit proper review and shall not include lump sum items which cannot be readily analyzed.

5.2.4.3 Cost Estimates:

The quantity surveys shall be priced with unit costs for labor, materials and equipment, presented separately, currently prevailing in the vicinity of the project and reflecting anticipated labor conditions due to the other work in progress or contemplated in the near future. Pricing of quantity surveys shall include the pricing of square foot areas and cubage. The total amounts for each line item or other directed project components and for the project as a whole shall be computed.

5.2.4.4 Target Cost:

The GEC-SYS shall report to the Authority with regard to the approved Target Cost at (a) 70% completion of each project design or (b) at any time that the GEC-SYS considers that the approved Cost Target may be exceeded.

5.2.4.4.1 In the event that changes to the basic design concept of the project are recommended by the GEC-SYS, these recommendations are to be accompanied by an analysis of their effect on the approved Target Cost.

5.2.4.4.2 In the event that changes to the basic design concept are initiated by the Authority, the GEC-SYS shall promptly assess the effects of these changes on the approved Target Cost and report to the Authority.

5.2.4.4.3 All other factors which significantly influence the estimated cost of the project, and which become apparent as design progresses, are to be fully documented and the Authority is to be kept well informed.

5.2.4.4.4 If, upon completion of the design, the GEC-SYS's final estimate exceeds the current Target Cost and it is shown that the procedures described above have not been followed, the GEC-SYS shall redesign at no additional cost to the Authority the project or elements thereof, as directed by the Contracting Officer, to reduce the estimated project cost to the Target Cost level.

5.2.4.5 Design Schedule:

The design schedule will be prepared by the Authority and issued with the task order. When determining the design schedule the Authority may request input from the consultant as to recourse availability but in general the schedule will be driven by Authority priorities.

5.2.4.6 Review Submittal:

5.2.4.6.1 Project Design Review Submittals, unless otherwise required, shall be made for each separate project design contract, at approximately the conceptual, 70%, and 100% completion of design. The submittal is to include documentation verifying resolution of all comments related to the preceding review.

5.2.4.6.2 Reports, Calculations, Drawings and Specifications:

Copies of reports, calculations and drawing and specification sets both paper and electronic shall be described in the task order. Electronic documents will be formatted as described in individual task orders. However, as a minimum electronic documents shall be in native format, portable document format (PDF) and rich text format (RTF).

5.2.4.6.3 Review Procedures:

In general, the Authority will complete the review in approximately 21 working days, after which review comments in writing and on marked-up documents will be furnished to the GEC-SYS. The GEC-SYS will meet with the Authority to discuss the review comments. Within ten (10) days after the review conference, the GEC-SYS shall deliver minutes of the conference, responding to all comments.

5.2.4.6.4 Review Scope:

Specifically, the review submittal shall include, but shall not be limited to, the following items:

5.2.4.6.4.1 The contract drawings in sufficient detail to define the design of all major elements, substantially complete and checked. Schedules of equipment and complete flow diagrams are to be included.

5.2.4.6.4.2 Two copies of design computations, substantially complete, indexed and checked.

5.2.4.6.4.3 Copies of specifications in draft form, but otherwise complete.

5.2.4.6.4.4 Statement of actions required of the Authority or by others which must be received to complete the design.

5.2.4.6.4.5 Comprehensive statement individually enumerating specific actions which are required by others to complement the design to enable construction to proceed on schedule, with particular attention to those items of construction indicated in the contract documents to be performed by others.

5.2.4.6.4.6 A complete and well-organized construction schedule shall be submitted showing the consultant's analysis of a probable or technically feasible construction schedule. The schedule shall be prepared to a level of detail consistent with the level of design. A narrative shall accompany the schedule explaining principal assumptions, criteria and production rates upon which the schedule is based.

5.2.4.6.4.7 Engineering estimates of cost of construction on the unit price schedule forms.

5.2.4.6.4.7.1 The Authority's review shall be confined to assuring that all assigned tasks were addressed. This review shall not relieve the GEC-SYS of its responsibility for complete and accurate design services.

5.2.4.6.4.8 Final Delivery of Contract Documents

5.2.4.6.4.8.1 After the review comments have been incorporated, or otherwise resolved, the GEC-SYS shall complete and submit the original contract drawings to the Authority. The original full-size contract drawings shall be checked, bear the professional registration seal, and be signed and ready for reproduction. The original specifications, with the cover, shall be checked, bear the professional registration seals of the various disciplines responsible and ready for reproduction. See Section 5.2.4.6.2.

5.2.4.6.4.8.1.1 The Authority owns all designs, computations, evaluations, investigation reports, and other professional documents and support data produced under this contract.

5.2.4.6.4.8.1.2 The following additional items shall be included among the final contract documents to be submitted to the Authority:

5.2.4.6.4.8.1.2.1 Engineer's final estimate of construction costs together with a copy of computations and back-up sheets in a sealed envelope marked "FOR CO EYES ONLY" and submitted to the CO.

5.2.4.6.4.8.1.2.2 One original copy of all checked design computations, sealed by a Professional Engineer licensed in the local jurisdiction, indexed and bound. See Section 5.2.4.6.2.

5.2.4.6.4.8.1.2.3 Construction planning schedule and related documents.

5.2.4.6.4.8.1.2.4 Comprehensive statement individually enumerating specific actions which are required by others to complement the design to enable construction to proceed on schedule. Particular attention is to be given to those items of construction indicated in the contract documents to be performed by others.

5.2.4.6.4.9 Continuation of Professional Services:

5.2.4.6.4.9.1 As stipulated in the General Provisions of the contract, the GEC-SYS shall provide follow-up engineering services as may be requested by the Authority during the construction phase of the work for which task orders may have been issued for construction services such as shop drawing review, inspection, etc.. Such services are required to correct errors or omissions in the contract documents, to make changes in the design as directed by revisions to the criteria or standards, to adopt the design to be consistent with modifications in the construction procedure, or for other reasons. Services required to make corrections because of errors or omissions on the original contract documents shall be provided at no extra cost to the Authority; services required for revisions or modifications may be considered to be governed by the provisions of the "Changes" article in the General Provisions of the contract.

6 REPORTING PROCEDURES:

6.1 Reports:

6.1.1 The GEC-SYS shall provide periodic reports to the Authority. The following reports are required:

6.1.1.1 Task Order Status Report

6.1.1.1.1 The GEC-SYS shall submit Status Reports on all task orders to the Authority monthly. The report shall be updated and contain current information. The report shall contain the following information:

6.1.1.1.1.1.1 A chronological listing of task orders.

6.1.1.1.1.1.2 The date the task order was received.

6.1.1.1.1.1.3 The task order number.

6.1.1.1.1.1.4 The engineer (s) assigned the task.

6.1.1.1.1.1.5 The scheduled due date.

6.1.1.1.1.1.6 Any revised due date.

6.1.1.1.1.1.7 The task order completion date.

6.1.1.1.1.1.8 The current status of the task.

6.1.1.1.1.1.9 The amount the task was issued