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THE STUDY ON AREA TRAFFIC CONTROL PROJECT IN BANGKOK IN THE KINGDOM OF THAILAND

SUPPLEMENTARY VOLUME PART 3

DRAFT TECHNICAL SPECIFICATIONS

FINAL

THE DETAILED DESIGN STUDY ON

AREA TRAFFIC CONTROL PROJECT IN BANGKOK

IN THE KINGDOM OF THAILAND

SUPPLEMENTARY VOLUME

PART 3

DRAFT TECHNICAL SPECIFICATIONS

FINAL REPORT

OCTOBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

PART G
TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

TECHNICAL SPECIFICATIONS

DIVISION I : GENERAL REQUIREMENTS

TABLE OF CONTENTS

TECHNICAL SPECIFICATIONS

DIVISION I : GENERAL REQUIREMENTS

1.0 STANDARDS TO COMPLY

All equipment the CONTRACTOR supplies shall be new and subject to acceptance tests to the satisfaction of the ENGINEER. Unless other standards are specifically required to be complied with herein or in the Contract, all materials and components used under the Contract and all design calculations and tests shall be performed in accordance with BMA standards.

In the absence of such standards in the BMA, various authoritative industry standards generally accepted and approved in one of the major industrialized countries such as Japan, U.S.A., Germany, and Great Britain shall be applied.

Whenever in the Plans or Specifications reference is made to the Japanese Industrial Standards (JIS), the American Standard Code for Information Interchange (ASCII), and the like, it shall be understood that equivalent standards will be accepted.

If the Tenderers offer materials, equipment, design calculations or tests which conform to standards other than specified standards, full details of the differences between the proposed standard and the specified standards shall be submitted when required by the ENGINEER.

All traffic signs as required in this specifications shall conform to standard signings used in Thailand.

2.0 MANAGEMENT

2.1 CONSORTIUM OR JOINT VENTURE

2.1.1 CONSORTIUM

The Prime CONTRACTOR of the consortium shall be fully responsible for any fault of the other constituent firms of the consortium. The Prime CONTRACTOR shall undertake the entire obligations under the Contract to the BMA just as though it had executed the Contract as one single CONTRACTOR for the Works.

2.1.2 JOINT VENTURE

The Prime CONTRACTOR of the joint venture shall act on the execution of the obligations under the Contract just as the Prime CONTRACTOR under the case of consortium described above. The representative officers of such joint venture company shall concurrently be senior members of the Prime CONTRACTOR.

Should the joint venture company become bankrupt or insolvent, or have a receiving order made against it, or compound with his creditors, or be a corporation commencing to be wound up, or be under any situation the BMA would feel uneasy to leave the execution of the Contract to their hands, then the Prime CONTRACTOR shall take over the entire obligations independently under the Contract just as though it were the single CONTRACTOR under the Contract.

2.1.3 ORGANIZATIONAL AND MEMBERSHIP CHANGES

Should the consortium or joint venture company which had been awarded the Contract ever undergo any membership or organizational changes or alterations, the BMA shall be advised beforehand for his consent on any changes or alteration.

2.2 CONTRACTOR'S PERSONNEL AND THEIR RESPONSIBILITIES

The CONTRACTOR shall provide all personnel necessary for the execution of the Works, such as the Project Superintendent, installation supervisors, and senior personnel to fulfill the CONTRACTOR's obligations under the Contract. These personnel shall be able to read, write and converse in English or in Thai.

At least one of the CONTRACTOR's personnel who are on assignment in Bangkok for the Project shall be capable of converse fluently in Thai; otherwise, a translator shall also be provided.

2.2.1 PROJECT SUPERINTENDENT

The Project Superintendent shall be bestowed with authority to receive and carry out the directions and instructions from the ENGINEER. The Project Superintendent shall be an engineer and well versed in the traffic control systems. He shall be resident in Thailand to fulfill the CONTRACTOR's obligations under the Contract and shall be given full responsibility to enter into negotiations regarding overall matters arising out of the Contract.

The Project Superintendent shall be primarily a full-time personnel for the execution of the Contract from the date of the written acceptance of the Tender to the issuance of the Certificate of Completion for the Whole Works. From the date of issuance of the Certificate of Completion for the Whole Works to the Final Acceptance, he shall be assigned to the Project at least on an as needed basis.

2.2.2 INSTALLATION SUPERVISOR

The CONTRACTOR shall appoint at least two (2) installation supervisors to supervise the installation activities. They shall also be resident in Thailand from the start of installation work. They shall be empowered to enter into negotiations regarding points arising from the installation work, so that the Work may be carried out with minimum delay. They shall be committed to the Contract on a full-time basis at least until issuance of the Certificate of Completion for the Whole Works.

2.2.3 SENIOR PERSONNEL

The CONTRACTOR shall assign two (2) senior engineers (one software engineer and one hardware engineer) and one (1) accounting officer to be full time participants to the Project during the course of the Works. They may be stationed in their home country, but shall be available in Thailand whenever the necessity arises. The senior engineers shall be involved in technical discussions and shall conduct the Training Courses and all testing procedures. The senior engineers shall also be involved in the installation works as necessary.

The CONTRACTOR shall also assign a full time maintenance supervisor, who shall reside in Bangkok, during the guarantee period.

2.2.4 PERSONAL VITAE

Within a month after the date of the Contract execution, the CONTRACTOR shall submit to the ENGINEER, detailed written statements including the names, duties, curriculum vitae of all foreign and local personnel candidates to be employed.

Where subsequent changes or additions in foreign personnel are proposed, these replacements or additions shall have at least equivalent experience and qualifications, and detailed written statements of their experience and qualifications shall be submitted to the ENGINEER prior to their assignment.

2.2.5 LOCAL SENIOR PERSONNEL

The CONTRACTOR shall employ at least three (3) senior local personnel under the Contract including engineering and technical managers in the field of electronics, computer or communication.

They shall participate in technical discussions, testing procedures and engineering activities of the installation works. They shall also be involved in all the maintenance activities including the period of the Guarantee Period Maintenance.

2.3 PROJECT MEETING

The CONTRACTOR shall be available for progress meetings which will be called for by the ENGINEER. The notice of such meetings shall be given by the ENGINEER in writing, and delivered to the CONTRACTOR's field office in Bangkok at least seven (7) days in advance of the planned meeting date.

2.4 PROGRESS REPORT

The CONTRACTOR shall prepare twenty (20) copies of progress report every month, and submit to the BMA through the ENGINEER. The format of the report shall be agreed upon by the BMA/ENGINEER and the CONTRACTOR.

3.0 TEST ON COMPLETION

3.1 GENERAL

The CONTRACTOR shall keep a clear record of all tests conducted. The record shall including time, place, equipment, functions, persons attending, and faults or problems encountered. The test results, even if they are not satisfactory, shall be documented and submitted to the ENGINEER for review.

3.2 TESTS ON COMPLETION FOR A PORTION OF WORKS

3.2.1 PROCEDURE

The CONTRACTOR shall give due notice to the ENGINEER seven (7) days in advance of the proposed date and contents of the Tests on Completion for a Portion of Works.

Tests on Completion shall be performed for the portions of Works completed in the previous one-month period. (Refer to Section 7.0 "Acceptance Procedure" of the Special Conditions of Contract).

When the ENGINEER has received satisfactory test results, he shall notify the CONTRACTOR in writing that the equipment is ready for trial operations. If the ENGINEER decides the equipment is not in accordance with the Contract, he may reject the equipment, and he shall inform the CONTRACTOR as to the reasons why the equipment was rejected in writing within a reasonable time.

3.2.2 TEST ITEMS

After the delivery and installation of the equipment at the site, tests on completion for that portion of Works shall be conducted for each equipment.

Appearance of the equipment and required operations shall be examined in this test. Tests on completion shall be conducted, as a minimum, for each of the following items:

(a) For signals:

1. Local controller functions
2. Signal heads and wiring
3. Detectors/push buttons
4. On-line operations from the front-end processor

5. Off-line operations
6. Signal related civil works
7. Railroad preemption mechanism

(b) For the Control Center:

1. Control keys and function keys on the control desk
2. Manual control operations
3. Interior finishing of the Control Center
4. Start-up and shut-down of central computer system
5. CPU functions
6. Front-end processor functions
7. Work station functions
8. Communication equipment
9. Detector data processing and recording
10. Wall map displays and control
11. Central equipment monitoring panel display
12. Traffic congestion degree validation
13. Emergency power supply equipment
14. Uninterrupted power supply operation

(c) For the CCTV system:

1. Camera operation
2. Monitor operation
3. Video recording system operation

3.3 TESTS ON COMPLETION FOR THE WHOLE WORKS

3.3.1 GENERAL

During the Test on Completion, all the functions of the equipment required under the Contract shall be tested. The tests shall be conducted with the attendance of the ENGINEER.

3.3.2 PROCEDURE

The CONTRACTOR shall submit, at least 14 days in advance, to the ENGINEER the date(s) on which the Tests on Completion for the Whole Works are to be undertaken.

The CONTRACTOR shall forward to the ENGINEER duly certified copies of the test results when the tests have been successfully completed. When the ENGINEER has received the test document and

is satisfied with the test results, he will notify the CONTRACTOR in writing that the whole works are ready for trial operations.

If major defects are uncovered in the tests, the CONTRACTOR shall prepare and submit to the ENGINEER for review and approval a proposal to remedy the defects. The CONTRACTOR shall not take corrective actions before the proposed remedies has received the ENGINEER's approval. Subject to the provisions of Section 7.9, "Minor Defects," of the Special Conditions of Contract, minor faults and defects detected during the Tests on Completion may be corrected during the trial operation period.

4.0 DESIGN REQUIREMENTS

4.1 GENERAL

All systems to be installed or modified under this Contract shall be capable of continuous, unattended, 24 hours a day, 7 days a week operation under the environmental conditions prevailing in Bangkok. Should the design require periodic replacement of any equipment or component, the replacement schedules of such equipment or component shall be described in the CONTRACTOR's Technical Proposal and in the maintenance manual.

4.2 DESIGN BRIEFING

Within 30 days of commencement date of the Works, the CONTRACTOR shall conduct a design briefing session in the Control Center on the proposed installations and modifications. The briefing shall cover all the system elements included in the Contract. The main objective of the briefing is to acquaint the ENGINEER and BMA staff with the proposed new installations and system modifications, and to allow them to examine whether or not the CONTRACTOR's design complies with the Contract.

The design briefing shall be conducted in conjunction with the work program briefing (see Section 6.2, "WORK PROGRAM," of Special Conditions of Contract).

4.3 DESIGN REVIEW AND APPROVAL

Within 90 days of commencement date of the Works, the CONTRACTOR shall submit a System Design report to the ENGINEER for his review and approval. The System Design shall provide detailed information, including design drawings, equipment layout diagrams, control algorithms, block diagrams, flow charts, calculation sheets and manufacturer's specification sheets, on all new installations and modifications and shall cover all necessary hardware, software and operating procedures.

The CONTRACTOR shall not, without specific approval in writing by the ENGINEER, place any material or component on order, nor commence manufacturing of any equipment or software coding until the System Design has been approved by the ENGINEER. The CONTRACTOR shall not implement any changes on the approved system design without prior approval of the ENGINEER.

The approval of the System Design by the ENGINEER, however, does not relieve the CONTRACTOR from delivering a fully operating and reliable system.

4.3.1 HARDWARE SYSTEM DESIGN

Hardware portion of the System Design shall include among others the following:

(a) A system block diagram for the signal and CCTV systems. The diagram shall show all existing and new elements of the systems with all changes clearly identified.

(b) Equipment layout of the Control Center.

(c) Monitoring panel, key board, and monitor layout, etc. on the control desk.

(d) Layout of the wall maps and CCTV monitors.

(e) Functional, environmental, and physical design specifications of each and every equipment and its components to be provided and/or their manufacturer's product specification sheets.

(f) Rust proofing treatments of outdoor equipments.

(g) Connections and interfaces between equipments.

4.3.2 SOFTWARE SYSTEM DESIGN

Software portion of the System Design shall include, as a minimum, identification of tasks, algorithms and parameters, priority levels, data file structure, parameter update procedures, data flow, calling sequences and programming languages. Update of parameters shall be done through formatted CRT editing screens unless otherwise approved by the ENGINEER.

4.3.3 OPERATING PROCEDURES

Operating procedures for all equipments and functional components of the ATC system shall be identified and described in detail in the System Design. Frequently used operating sequences shall be described in a step by step manner.

4.4 ENVIRONMENTAL CONDITIONS

All equipment shall be designed to operate properly under the environmental conditions normally encountered at the site of the equipment in Bangkok and shall conform to the minimum requirements specified herein.

4.4.1 TEMPERATURE AND HUMIDITY

Unless specified otherwise, indoor equipment shall be designed to operate in the temperature range of 10 to 40 degrees Celsius, and the relative humidity range of 30 to 90 percent, whereas outdoor equipment shall operate in the ambient temperature and relative humidity ranges of 5 to 60 degrees Celsius and 40 to 100 percent non-condensing humidity respectively. Adequate protection from moisture condensation, fungus, rust, insects, rodents, and dust shall be provided.

All equipment shall be adequately treated to prevent rust and corrosion due to high humidity or moisture condensation. All galvanized steel surface shall have a minimum plated zinc amount of 350 g/m^2. Any signs of rust or corrosion occurring within the guarantee period shall be deemed a defect and the CONTRACTOR shall be responsible for correcting, at his own expense, the defect to the satisfaction of the ENGINEER.

4.4.2 WIND

All outdoor equipment and their support, individually and fully assembled and installed as a whole, shall withstand an instantaneous wind velocity of at least 120 km/h.

4.4.3 EARTHQUAKE

The coefficient for earthquake load to be used in designing structures shall be K=0.15.

4.5 CABLING AND WIRING

All cables and wires shall be of good quality, conforming to normally accepted industry standards such as JIS, and shall be of the proper type and have sufficient ratings for the particular application.

All exposed ends of uninstalled cables and wires shall be coated with water tight sealing compound or sealing tape to avoid damage to conductors. All communication cables used shall have a clearly marked label securely fixed near each end in accordance with the cable network diagram.

All cables and wires shall be adequately protected from the edges of equipment housing or other surrounding objects. All of the cables and wires shall be neatly arranged and securely placed in such a way that all terminals are relieved of the weight of the cables. Terminals shall be coded and identified according to wiring diagrams. Live metal shall be recessed or protected to avoid accidental contact.

4.6 GROUNDING

All exposed metal not forming part of the electrical circuitry, including equipment enclosures and cable supports, signal pole shall be grounded to the earth.

Equipment which are supplied with voltages of 100V or more shall be provided with grounding terminals insulated from their frames. Control center and substation (power supply and generator room) equipments shall be equipped with a grounding terminal of earth resistance 10 ohms or less. Field equipments shall be equipped with a grounding terminal of earth resistance of 100 ohms or less. (See Plan No. 1224)

Compensation for furnishing and installing grounding equipment shall be included in the prices of various bid items and no separate payment shall be made therefor.

4.7 PROTECTION AGAINST LIGHTNING

All outdoor equipment shall incorporate gap arresters or other suitable device approved by the ENGINEER to prevent lightning damages which may enter through input AC lines, communication cables, or other metallic elements exposed to the open air.

Compensation for furnishing and installing lightning protection equipment shall be included in the prices of various bid items and no separate payment shall be made therefor.

4.8 CABINETS

All equipment cabinets for outdoor uses shall be of rainproof and rustproof construction with smooth exterior and adequate protection against moisture condensation and shall be made of high quality steel or stainless steel plates of adequate thickness. Steel plate cabinets shall be hot-dip galvanized and bake finished or treated with equivalent rustproof measures.

Past experience has indicated that condensation may develop inside a completely enclosed outdoor cabinet connected with underground conduit due to breathing effect which is caused by a change in ambient temperature even when the conduit is sealed by foamed sealant. The Tenderer shall state in his Technical Proposal how he will overcome this problem.

Cabinet doors shall permit complete access to the interior of the cabinet and shall encompass essentially the whole area of the front surface of the cabinet. All door hinge pins shall be of stainless steel construction.

All outdoor equipment cabinets shall be equipped with a build-in lock. All cabinets for the same type of equipment shall have an identical lock. A total of 25 keys for each type of cabinet shall be furnished to the ENGINEER.

4.9 POWER SUPPLY AND TOT TELEPHONE LINE

The input power supply of any equipment shall not be connected to any electric components except arresters without connecting first through fuses, power switches and circuit breakers.

All equipment shall be provided with a clearly visible label indicating the input power supply type (AC or DC) and voltage. All equipment shall operate with the power supply of 220V plus 15 percent or minus 20 percent, and 50 hertz plus or minus 4 percent.

The power supply voltage available in the field will be 220 V AC. Unless specified otherwise or with the approval of the ENGINEER, all field equipment shall be designed to operate directly on 220 V AC. The CONTRACTOR shall be responsible for arranging the terminal devices necessary to receive the power supply.

The CONTRACTOR shall provide three circuit breakers with switch, a meter base and power cable of suitable rating from one circuit breaker to the equipment at each power receiving point (See Plan No. 1210). Installation of power supply cables shall conform to the requirements of the utility company.

The CONTRACTOR shall also provide, for TOT telephone line, a line switch, line fuse and PD in a TOT line box, and line cable of suitable rating from the PD device to the equipment at each signal

receiving/sending point (See Plan No. 1210). Installation of TOT telephone line cables shall conform to the requirements of the utility company.

4.10 RADIO INTERFERENCE

All data processing and transmission equipment shall be designed to prevent radio interference with the satisfactory operation of other equipment regardless of whether the interference be due to radiation, induction or conduction.

Vehicle detector units shall be designed to operate normally in the presence of radio interferences.

4.11 DESIGN LIFE

All components and materials used in this Contract, excluding consumable items such as lamps, shall be of a design life of 10 years or longer unless specifically stated otherwise in the Specifications. The ENGINEER may approve components with a shorter design life if they are easily replaceable and a 10-year design life is generally considered infeasible or uneconomical. The replacement of such equipment shall be possible without displacing other component.

4.12 METERING

All electrical and electronic equipment shall be provided with waveforms and voltage test points or voltage meters as necessary for indicating circuit conditions.

4.13 FACTORY TESTS, INSPECTIONS AND CERTIFICATION

All equipment, components, spare parts, and software to be delivered or installed under this Contract shall be tested, inspected, and certified prior to delivery in accordance with these specifications.

4.13.1 CONTRACTOR'S QUALITY CONTROL MANAGER

The CONTRACTOR shall designate a single Quality Control Manager for all equipment to be supplied under the Contract. This individual must have experience as a quality control manager, and he shall not report to production personnel. If he wishes, the ENGINEER shall communicate directly with the Quality Control Manager and his superior, the latter to be defined by the CONTRACTOR. The

Manager shall be appointed early in the system design stage, and shall be involved in the design related discussions. The Manager shall ensure that the personnel undertaking the tests are not the same personnel who are involved in the production of equipment.

4.13.2 TEST PROCEDURES

For off-the-shelf or routinely manufactured equipments or components, a test or inspection certificate shall accompany each delivery. In addition, the CONTRACTOR shall submit the factory's routine testing procedures to the ENGINEER for review if so requested.

For equipment or components requiring special order or tooling, the CONTRACTOR shall submit to the ENGINEER proposed factory test items and test procedures for review and approval as soon as the System Design is approved. The test items shall include as a minimum the following:

(a) Power supply tests (all equipment)
  - input and output
  - fluctuation
  - instantaneous interruption
(b) Functional tests (all equipment)
(c) Environmental tests for temperature and humidity ranges as specified (sampling test)
(d) Insulation resistance (sampling test)
(e) Dielectric strength (sampling test)
(f) Rainproof test (sampling test)

Equipment Interface Tests -- Equipment interface tests shall be conducted for all computer and communication equipments in the factory. These tests shall be executed by interfacing as many different kinds of equipment as possible so as to ascertain their suitability as system components. Where there is no appropriate equipment at that particular time to connect to a certain equipment, the tests shall be executed by connecting to a simulator.

The CONTRACTOR shall notify the ENGINEER at least 14 days in advance of each sampling test to be undertaken and shall make arrangement for the ENGINEER to attend the test if requested. Should the ENGINEER or his designated representative decide not to attend any of the tests, the tests shall be carried out under the direction of the Quality Control Manager, and the Quality Control Manager shall forward to the ENGINEER duly certified copies of the test results.

If the ENGINEER is satisfied with the test results, he shall notify the CONTRACTOR in writing to that effect, and the CONTRACTOR may then ship the equipment. If the ENGINEER decides that equipment is defective or produced not in accordance with the Contract, he may reject the equipment, and will inform the CONTRACTOR of the reasons in writing within 21 days.

4.13.3 DEFECTS

Should a defect be detected during one of the tests, the cause of the defect shall be ascertained and documented. For minor defects which do not require re-design of the equipment, the defect shall be rectified and the test be repeated. If a design change is required, the ENGINEER shall be so informed and the revised design shall be submitted to the ENGINEER for review and approval.

4.13.4 TEST CERTIFICATE

Test certificates will be issued only for the actual equipment that have passed the tests. For sampling test of equipment, if any defect is detected in any one sample, the entire lot shall be tested and the results shall be reported to the ENGINEER for his review.

4.13.5 INSPECTION

All equipment shall be inspected before delivery and upon arrival at the Site. The inspection shall be performed on the following items:

(a) Painted surfaces and color
(b) Condition of assembling
(c) Design and dimensions
(d) Parts arrangement

4.13.6 COST OF TEST AND INSPECTION

The testing cost allowed for shall cover full cost of providing all facilities, labor, consumable parts, and appliances required in connection with all inspection and tests of completion on the site or on the manufacturer's premises, and all other expenses as may be required for passage of the Engineer or his representative to attend the tests.

5.0 INSTALLATION

5.1 REMOVAL OF EXISTING TRAFFIC SIGNAL EQUIPMENT

Where traffic signal equipment installed by the CONTRACTOR is to replace existing traffic signal equipment, it shall be the responsibility of the CONTRACTOR to remove all or portion of the existing signal equipment including signal heads, controller, cable, traffic signal poles, and catenary wires. However, no such equipment shall be removed from any location until the new traffic signals are working to the satisfaction of the ENGINEER and the ENGINEER directs that the old equipment be removed. All such equipment shall be delivered by the CONTRACTOR to a storage area in Bangkok to be nominated by the ENGINEER.

5.2 TRANSITION BETWEEN OLD AND NEW SIGNALS

Prior to the completion of traffic signal works at any location the CONTRACTOR shall ensure that all newly installed signal heads erected under the Contract are completely and securely covered so that they are not visible to motorists or pedestrians. Unless otherwise directed by the ENGINEER, the CONTRACTOR shall not in any way interfere with the normal operation of any existing signal equipment.

Subject to prior approval from the ENGINEER and subject to there being a traffic policeman on duty at the signal location, the CONTRACTOR may switch on new signal installation for the purpose of testing. If there are existing signals at the location then these shall be switched off immediately prior to any such testing. At no time shall the CONTRACTOR allow the old and new signals equipment to operate simultaneously.

For traffic signal works where existing signal equipment are to be used, the transition from the old to the new system will subject to the prior approval of the ENGINEER and the presence of traffic police to effect traffic control, whereby the existing signals are to be temporary disconnected and without any unnecessary delay, the existing equipment to be used are then connected to the new system. Such transition work shall not take more than two (2) days to accomplish at any one intersection.

"Before ATC starts to operate, proposed signal timing plans as well as parameters of traffic-responsive operation of each of the intersections, links and groups of intersections should be examined in the field individually one after another and necessary amendments on the timing plans or parameters should be made if any inappropriateness is found".

"After the above mentioned procedure for examining and tuning the plans and the parameters, the signals should be brought back to the existing manner of control with the existing plans until ATC starts to control all of the intersections in the whole ATC area simultaneously. This is for the purpose of avoiding that the benefit of signal control improvements is cancelled out by possible increase of traffic demand which may take place gradually if ATC operation starts piecemeal".

5.3 AUTHORITY TO EXCAVATE

The CONTRACTOR shall be responsible for obtaining authority to excavate roads or sidewalks from government agencies concerned.

The application should be made in ample time for its approval before starting of excavation.

5.4 DAYS AND HOURS OF WORK

Without the consent of the ENGINEER, no excavation or restoration work involving complete or partial blocking of a traffic lane, shall be done during "Peak Hours". The "Peak Hours" are generally as follows:

Monday to Saturday
7:00 a.m. - 9:30 a.m.
12:30 p.m. - 2:30 p.m.
4:00 p.m. - 6:30 p.m.

The above peak hours designation may varies from time to time under special circumstances or as required by other traffic-related agencies or as directed by the ENGINEER.

5.5 CONDUIT INSTALLATION

5.5.1 GENERAL

Conduit shall be rigid steel type as required by MEA, suitable for underground electrical installations including those at railroad crossings.

(Tenderers should note that any specifications that may have been shown as PVC in the drawings for field installation shall read as Steel instead).

Conduit installation shall include trenching, bedding, placement of conduit, backfilling, and restoration. Conduits shall be installed as indicated on Plan No.1225 and as specified herein.

The CONTRACTOR shall be responsible for restoring the surfaces to its original conditions. It shall be noted that some sidewalk has a decorated surface and the CONTRACTOR shall restore the surface as closely as possible to the original condition using the same or similar materials. Compensation for restoring the surfaces shall be included in the items paid for conduit installation and no separate payment shall be made therefor.

Before commencing excavation, the contractor shall make a detailed survey of the site to determine the actual site condition particularly as to the existence of items buried underground.

5.5.2 TRENCHING

The excavations required for the installation of conduits shall be performed in such a manner as to avoid any unnecessary damage to streets, sidewalks, landscaping, and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the conduit. Excavation shall not be performed until immediately before installation of conduits.

The outline of all areas to be removed in pavement and any improved hard surfaces shall be cut to a minimum depth of 50 mm with an abrasive type saw prior to removing the improved surface material. Cuts shall be neat and true along score lines, with no shatter outside the removed area. Trenches shall be excavated to the required depths as indicated on the Plans and as specified below:

(a) Conduits in roadways and crosswalks shall be installed at a depth of at least 600 mm below the roadway level.
(b) Conduits running longitudinally in sidewalks and roadway shoulders shall be installed at least 600 mm clear of the edge of the curb line or roadway and at least 300mm below the sidewalk or road shoulder level.
(c) Conduits in the median shall be installed at least 300mm below the median surface level.

If physical conditions on site necessitate changes from the above requirements, the CONTRACTOR shall obtain the approval from the ENGINEER.

5.5.3 BEDDING OF EXCAVATION

Before conduits are laid, the trench beds shall be levelled and sand placed on the bed and hand tamped to a thickness of not less than 50 mm. All conduits shall be covered by a layer of sand hand tamped to a thickness of at least 50 mm above the crown.

5.5.4 CONDUIT

Care shall be taken in installing conduits so as not to damage the conduit or allow the intrusion of water, gas, or foreign matter from without during and after the installation.

Efforts shall be made to provide suitable gradient to conduits leading to handholes to prevent the accumulation of water within the conduits. The joints for underground conduits shall be such as to prevent the ingress of foreign matter; adhesive shall be used.

To ensure minimum resistance from friction when pulling cables and to avoid damages from future excavations, conduits shall be routed straight or along the contour of the roadway as much as possible.

Cut edges of conduits shall be properly reamed. The end of conduits shall be finished so as not to damage cables.

The curvature radius of installed conduits shall be 10 m or more wherever possible and in any cases shall be no less than 2.5 m.

5.5.5 BACKFILLING AND RESTORATION

For excavation in roadway shoulders, existing turf shall be carefully removed, stacked and periodically watered for later re-use. The remaining excavated materials may be stock piled on the site for later backfilling but excavated topsoil shall be kept separate.

For excavation in roadways and footpaths, selected granular material, excavated premix and sub-base may be stock-piled on site for later backfilling. All other unsuitable excavated material must be removed. All excavated material shall be kept clear of the roadway and sidewalk at all times.

If, for unavoidable reasons, a trench running laterally across a roadway cannot be backfilled and must be left open overnight or for a longer period of time, steel plates, securely bolted and adequate to take traffic loading shall be placed across the trench and the section of road shall be opened to traffic.

For excavation in roadway shoulder berms and slopes the excavated material shall be replaced in 150 mm layers in the reverse order to which the material was excavated. Each layer shall be compacted with a power driven rammer. If the existing surface is landscaped or protected with turfs, the top 150 mm of the excavation and adjacent disturbed ground shall be filled with good loamy topsoil and hand tamped.

For excavations in asphalt roadways and footpaths the backfilling shall be done in 150 mm layers to within 300 mm of the surface level using clean sand and suitable excavated granular material, or other approved granular material. Each layer shall be compacted using a power driven rammer. The next 250 mm of backfill shall consist of crushed gravel base laid and compacted by a power driven rammer in two 125 mm layers. A tack coat of bituminous emulsion (40%) shall be applied to the final surface of the crushed gravel at a rate of 1.5 sq.m./liter. A wearing course of premix asphalt evenly placed over the treated stone surface and rolled until complete consolidation has been obtained and the resultant wearing surface left 15 mm above the adjacent undisturbed surface. For consolidation of the premix asphalt a 6-8 ton diesel powered roller shall be used.

5.5.6 MAINTENANCE OF DRAINS AND SERVICES DURING EXCAVATIONS

The CONTRACTOR shall ensure that he has full knowledge of the location of all drains and services in the area of any excavation prior to the start of excavation. The CONTRACTOR shall ensure that all precautions are taken not to disturb such drains and services and shall be responsible for their maintenance during the excavations and restorations.

The CONTRACTOR should note that the site of the Works is subject to frequent and heavy rainfall and all precautions shall be taken to maintain existing drainage ways to prevent flooding.

5.5.7 RESTORATION OF DRAINS AND PRECAST UNITS

The CONTRACTOR shall carry out the restoration of all existing precast channel drains, gullies, pavement slabs, dividers, curbs, etc. which have been affected by any trench opening. Only excavated units in a sound and undamaged condition may be replaced otherwise the CONTRACTOR shall supply and lay similar new units. The units shall be replaced to original line and level and bedded, backed and jointed to the satisfaction of the ENGINEER.

5.5.8 COMPLETION OF WORKS

On completion of restoration works at any one site, the CONTRACTOR shall clear away all debris, surplus materials and plant and leave the site in a clean and tidy condition.

5.5.9 MAINTENANCE OF EXCAVATION AND RESTORATION

The CONTRACTOR shall be responsible for the proper maintenance and good condition of each excavation and each restoration work up to a period of 6 months after restoration.

All excavation sites prior to, during, and after restoration shall be maintained in a sound and firm condition, free from depressions, humps, loose stones, and any other similar defects so as not to constitute danger or unreasonable nuisance to traffic or members of the public. Loose materials or stones shall not be allowed to accumulate over or around any excavation but shall be promptly swept clear.

Any part of any restoration work in a sidewalk or roadway that settles more than 15 mm below the adjacent undisturbed surface level shall be promptly resurfaced.

Should the CONTRACTOR default in the maintenance of excavations and restorations and, in the ENGINEER's judgement, such default would constitute in any way a traffic hazard, the ENGINEER shall have the power to attend forthwith to such defects and the entire cost of the work shall be borne by the CONTRACTOR.

Before the expiration of six calendar months from the ENGINEER's written approval of restored works, the CONTRACTOR shall write to the ENGINEER for final inspection of the work to determine any outstanding defects which have to be rectified. The CONTRACTOR will only be absolved of all the responsibilities of the maintenance after such defects are rectified to the satisfaction of the ENGINEER.

In the event that the CONTRACTOR fails to request the ENGINEER for final inspection at the end of the six months period, the maintenance period of each item of work shall be deemed to have been extended by the CONTRACTOR due to his fault to such a time until the final inspection is carried out.

5.5.10 CONDUITS FOR BRIDGES AND CULVERTS

Conduits for bridges and culverts shall be steel conduit and laid exposed on the concrete surfaces or suspended at intervals as specified below:

(a) At 1m from the point of abutment or separation towards the expansion joint of the conduit on the bridge.

(b) 1m away from a junction box where a box exists.

(c) 1m away from the expansion joint if it exists in the middle of a bridge.

(d) In addition to above, (a) through (c), saddle supports shall be placed with equal intervals of 4m or less.

(e) A handhole shall be installed at each ends of the bridges and culverts.

Suspended conduits shall be firmly fixed to the positions specified above by employing metal suspension fixtures and taking ample precautions to prevent damage from falling objects.

5.5.11 TEST OF CONDUIT

The conduit shall be checked for alignment and freedom from foreign matter by passing two brushes attached to the ends of an iron or hard wooden mandrel followed by a cable rope, one each direction. The diameter of mandrel used shall be smaller than the nominal diameter of conduits by not more than 10mm and its length shall not be less than 50 cm. The diameter of the bristles on the brush shall be at least 6 cm greater than the nominal diameter of the conduits and the length of each brush shall be at least 8 cm. The operation of laying the cable shall be commenced only after the work to be utilized has been approved by the ENGINEER.

5.6 SIGNAL AND COMMUNICATION CABLE

Signal and communication cables for detectors shall be CVV for underground installation and CVV-SS for aerial installation. Cable sizes shall be 6-, 8-, 12-, and 20-conductor. Communication cable between field equipment and TOT terminating board shall be CPV, 0.5 mm.

Wire gauge shall be suitable for the lamp load with at least 50% safety factor. Wire insulation sheath shall be color-coded for easy identification.

Each cable run shall contain at least one (1) spare conductor.

5.6.1 TESTING AND DELIVERY

The CONTRACTOR shall test each drum or spool of cable for compliance with requirements of these specifications.

After testing, the cable shall be sealed and securely packed on the drum for transport.

The CONTRACTOR shall supply records of the results of all tests performed on the cables.

Length, fault levels, conductor insulation faults, conductor resistance and capacitance measurements, and cable dimensions shall be presented to the ENGINEER not later than the day of delivery of the cable to the BMA designated storage site.

5.6.2 INSPECTION

The cables shall be subject to inspection at the place of manufacture by the ENGINEER or an ENGINEER's appointee, who shall be given every facility to inspect them at any time during manufacturing.

5.7 CABLE INSTALLATIONS

5.7.1 GENERAL

The CONTRACTOR shall furnish and install the required wiring between the local controller, the signal heads, vehicle detectors, power switch box, and TOT telephone line terminal box.

Underground cables shall be installed in conduits. Aerial cable shall be mounted on MEA power poles. Aerial cable installations shall conform to MEA standards.

5.7.2 PULLING CABLES

Cables shall be pulled into conduits by hand or by using an approved tensioning device according to manufacturer's recommendations. Care must also be exercised to avoid wrinkling and tearing of the nylon jacket.

5.7.3 SPLICES AND HANDHOLES

All underground installations shall include handholes at intervals of approximately 100 meters and wherever the conduit changes direction by more than 45 degrees. There shall be no underground splices except at handholes. However, there shall be no splicing between local controller and TOT terminating board.

All splices shall be made permanently water-proof using an approved enclosure. Splicing shall be mounted on the cable hanger attached to the handhole wall and cables at both ends shall be fastened to the cable hanger in orderly way. If splicing is not to be carried out immediately after cable installation, the cables will be sealed in an approved manner. If the cables are to be left for more than three (3) days, the ends shall be sealed with an approved epoxy resin.

At termination points of cables and where cables are spliced, a minimum of two (2) meters but not more than 2.5 meters of slacks shall be provided for re-splicing if necessary. The slacks shall be laid neatly in the handholes.

Where a cable terminates in a handhole or manhole, the end of the cable shall be sealed against the ingress of moisture, using an approved method.

Where a cable terminates at a distribution frame the cable shall be split, and approved epoxy resin moisture seal shall be applied after soldering each of the wires to its appropriate distribution frame termination.

5.7.4 CONNECTION BETWEEN UNDERGROUND AND AERIAL CABLES

Where an aerial cable is used, the connection between the underground and the aerial cables shall be made through a steel conduit attached to the pole which supports the aerial cable. In no circumstances shall an unprotected vertical cable riser be approved (See Plan No.1226).

Splices between the vertical riser cable and the underground cable shall normally be done in an approved pole mounted junction box.

5.7.5 INSTALLATION TESTS

Each installed cable shall be tested as follows:

(a) Loop resistance and insulation resistance to earth shall be measured for 10% of the cable pairs for each section of installed cable before splicing. The length of each section shall also be measured.

(b) The above measurements shall be tabulated, together with expected values calculated from the measured length and the cable manufacturer's test results. These tabulations shall be submitted to the ENGINEER for review. The insulation resistance shall be 50 MOhms-Km or more between wires in a cable and between wire and earth when measured by a 250V merger.

(c) Should the difference between any measured value and its corresponding rated value exceed 10% of the rated value, or if in the opinion of the ENGINEER any of the results indicate a cable fault then the cable shall be removed and re-installed.

5.7.6 INTERSECTION WIRING

A complete set of intersection and pedestrian crossing wiring schematic drawings will be furnished to the CONTRACTOR for the installation of signal cables at each location. These drawings will indicate the type and the number of cables to be installed in each conduit run. All wiring connections shall be done through wiring terminals in signal poles or in cabinets and no splicing of conductors in handholes shall be permitted unless otherwise authorized by the ENGINEER.

The CONTRACTOR shall review the wiring schematics before actual field installation and shall report any discrepancies to the ENGINEER promptly. The CONTRACTOR shall install additional cables, if necessary, to complete the signal installation as intended.

5.8 HANDHOLES

Construction of handholes shall conform to Plan No.1227 and No.1228 and these specifications.

The CONTRACTOR shall be responsible for restoring the surfaces to their original conditions. Compensation for restoring the surface conditions shall be included in the items paid for handholes and no separate payment shall be made therefor.

Bell mouths shall be provided at the end of conduit to prevent damage to cables. For handholes where cables are jointed, cable hanger of suitable size shall be provided to secure cable joint.

5.9 FOUNDATIONS AND FOOTINGS

Construction of foundations and footings for signal poles and equipment cabinets shall conform to the Plans and these specifications.

5.9.1 MOLDING AND FRAME

Molding frame shall be made of dried wood. The frame shall be of such quality and strength as will ensure complete rigidity during pouring, ramming, setting and curing of the concrete.

Wooden molding frame shall be planed to secure a good surface and shall be coated with a concrete-separating chemical.

5.9.2 ASSEMBLING OF REINFORCING BAR

The processed reinforcing bars shall be placed at their designated portion after removing any rust or oily spots and shall be assembled firmly so that they will not move when concrete is poured.

Where major portions of the reinforcing bars intersect, the reinforcing bars shall be tightly secured with iron wires having a diameter of more than 0.8mm.

5.9.3 DETAILS OF MIXING

The amount of concrete mixed in any one batch shall not exceed the rated capacity of the mixer. Concrete shall be mixed until a mixture of uniform color and consistency is obtained.

In case of manual mixing operation, first cement and sand shall be mixed more than 3 times on a water-tight mixing plate. Then gravel and water shall be added and all the materials shall be mixed more than 3 times until uniformity in color and quality is achieved as in mechanical mixing.

5.9.4 POURING/CASTING

Pouring or casting of concrete shall be carried out carefully by rod stamping and by the use of vibrators in such a manner as to evenly permeate to every nook among the reinforced bars and other materials within the mold.

In case of segregation between aggregate components occurs during transportation, proper mixing shall be done again without adding additional water before use.

Each single operation shall be carried out nonstop from start to finish.

In case of pouring or casting concrete directly on an existing concrete portion, the surface of the portion concerned shall be washed with water and roughened by chiseling before placing the new concrete.

5.9.5 CURING

Concrete once mixed shall be used within a maximum time of one and half hour and any unused material left after expiry of one and half from the time of mixing shall be discarded.

Concrete shall be prevented from drying too rapidly by shielding it from sun and wind. The concrete shall be kept moist for seven days by covering it with saturated sack cloth and sprinkling frequently with water.

Whenever necessary, placed concrete shall be covered to protect it against excavated material from falling on it. Any foreign matters falling in spite of precautions, shall be carefully removed.

5.9.6 REMOVAL OF MOLDING FRAME

After completing the curing time, the molding frame shall be removed.

5.9.7 MORTARING

Mixing of mortar shall be done on the basis of 1 part cement and 2 parts sand, and thickness of mortaring shall be 15mm as standard. The surface area to be mortared shall be clean and wetted sufficiently with water.

5.10 WORK AREA SAFETY AND TRAFFIC CONTROL

5.10.1 GENERAL

Obstructions and excavations in work areas shall be adequately fenced and guarded at all times and proper traffic control devices shall be installed to protect the workers and the public. Particular attention shall be paid to the positioning of traffic barriers and traffic cones. Unnecessary blocking of traffic lanes shall not be permitted. Roads and sidewalks shall not be used for the unnecessary storage of materials.

Adequate traffic control devices shall be in place before work begins and all such devices shall be removed immediately when the work is completed. As work progresses, warning devices which were appropriate at one time but are no longer applicable shall be removed immediately.

Signs, lights, barriers and other traffic control devices shall be maintained in good order and in the correct position day and night. Signs shall be neat, clear and legible at all times.

Compensation for meeting the requirements of this Section shall be included in the various items bid and no separate payments will be made therefor.

5.10.2 LANE CLOSURE

No lane closure shall be permitted on any road during peak hours as defined in Section 5.4 except with prior approval of the ENGINEER. During non-peak hours, one or several traffic lane may be closed provided that at least one lane in each direction is open for traffic at all times. On two-way, two-lane roads, any lane closure shall be first approved by the ENGINEER. Notwithstanding the provisions above, the ENGINEER and the police shall have the power to order the lane closure removed or to require better traffic control measures.

5.10.3 WARNING SIGNS

All work area warning signs shall conform to the requirements of the BMA and these specifications.

A "LANE CLOSED AHEAD" and a "LANE CLOSED" sign shall be placed upstream of the lane closure site at a distance of approximately 100 meters and 50 meters respectively when one lane of the roadway is closed. These signs shall be placed further upstream of the work area if more than one lane of the roadway are closed.

All work area warning signs shall be reflectorized if the signs are to remain in place during hours of darkness.

5.10.4 TEMPORARY WARNING FLASHERS

Temporary warning flashers shall be used during the hours of darkness if traffic cones, barricades or other barriers are to remain in position at night. Lamps shall be kept alight at all times during the hours of darkness. The flashers shall clearly mark the site of obstructions and delineate the transition zone.

5.10.5 TRAFFIC CONES

Traffic cones shall be placed on the roadway in advance of the work site to form a transition taper. The length of the transition taper shall be at least 30 meters so as to guide traffic smoothly from the full width section to the narrowed down section. Spacing between the cones shall be no more than 10 meters.

5.10.6 PLANT AND EQUIPMENT

In all cases where traffic is permitted to use the whole or a portion of the existing road before the work is completed, all plant items and similar obstructions shall be removed from the road at night, if at all possible. Otherwise, they shall be delineated at night if within 2 meters of the edge of the roadway by two red lights suspended vertically from the point of obstruction nearest to the roadway. The lights may be omitted in cases where there are permanent obstruction, such as trees less than 2 meters from the edge of roadway and the plant or equipment are not closer to the road than the permanent obstruction.

During the day, a red flag shall project beyond the extremity of all plant items (other than vehicles) adjacent to the traffic lane.

5.10.7 VEHICLES

Vehicles which are used to carry out operations on the roadway and which are required to travel slowly or to stop frequently shall be made as conspicuous as possible. This shall be achieved by painting them in a distinctive color or painting the rear portion with diagonal stripes of a contrasting color or providing flashing lights on the top of the vehicle. They shall also have a plate on the rear side with the words "Slow Moving".

6.0 TRAINING

6.1 GENERAL

A training program as specified herein shall be provided for the management, operation, and maintenance of the system and its individual components. All training shall be conducted in Bangkok.

The CONTRACTOR shall develop all material required for the training in English and furnish twenty (20) copies of each manual, class note, visual aid, and other instructional material to the BMA for distribution to the attendants. The manuals, instructions, and training notes shall be in loose-leaf binder form.

The outline of the lectures or demonstrations and a sample or description of all training aids shall be submitted to the ENGINEER for review at least ninety (90) days prior to their proposed presentation or use. Written approval by the ENGINEER of this material shall be required prior to the scheduling of training sessions and/or the production in quantity of any training materials.

The minimum content and duration (contact hours) of classroom training sessions shall be as specified herein, plus such other topics as are necessary, to ensure effective training. Notwithstanding the contact hours specified herein, all training shall be effective and shall be completed by the CONTRACTOR to the satisfaction of the BMA.

6.2 MANAGEMENT AND OPERATIONS TRAINING

The management and operations training shall include classroom instructions, on-site demonstrations, and follow-up reviews. The training shall be designed for BMA engineers and Control Center Operators (up to 20 persons) and shall cover all operating procedures and database management of all equipments of the signal and CCTV systems.

The initial classroom instructions and on-site demonstrations shall be completed within three (3) months of the issuance of the Certificate of Completion for the Whole Works and the follow-up reviews shall be completed during the last two (2) months of the guarantee period. The contents of this training shall include as a minimum the following:

(a) System Management (Minimum of 8 contact hours)
- System structure
- Operations overview
- Data requests and data displays
- Functions and duties of control center personnel

(b) Control Procedures (Minimum of 24 contact hours)
- Computer and peripheral equipment operations
  . Orderly start-up and shut-down
  . Loading and execution of programs
  . Bring on-line and drop intersections
  . Use of diagnostic programs and procedures
  . Response to alarms, errors and faults
  . Use of peripherals
  . Operation of the signal system equipment
  . Operation of closed circuit television equipment.

- Interpretation of alarms and fault messages
- Wall map and CRT displays
- CCTV operations

(c) Analyst Procedures (Minimum of 24 contact hours)
- Data requests and data displays
- Data base management
  . Coding input
  . Edit checks
  . Insertion and deletion of data
  . Modifications
  . Addition or deletion of signals
  . Addition or deletion of detectors
  . Changing control areas
  . Changing parameters.
  . Changing signal phasing
- Interpretation of displays and reports
- Use of PROM writer

6.3 MAINTENANCE TRAINING

The maintenance training shall cover trouble shooting and maintenance procedures for all newly installed equipment and the use of maintenance tools, equipment, and test instrument. The training shall also cover modification of control boards and other components of the local controller necessary to effect phasing changes or implement a

revised locally stored fail-safe timing plan. It shall be completed within six (6) months of the issuance of the Certificate of Completion for the Whole Works. The training shall include at least 80 contact hours of classroom instructions and hands-on workshop sessions, and on-the-job training.

The classroom lectures shall cover at least the followings:

- Control Center
  - . Computer
  - . Front-end processors
  - . Peripherals
  - . Communications
  - . Modems
  - . Cable
  - . Transmitters

- Field equipment
  - . Controllers
  - . Interface
  - . Detectors
  - . Trouble shooting
  - . Furniture (poles, signal heads, etc.)
  - . Lamps
  - . Television cameras

- Workshop
  - . Test equipment
  - . Test procedures
  - . Repair procedures

On-the-job maintenance training shall be provided for BMA maintenance staff (up to 15 persons) and shall commence on the conclusion of the classroom and workshop training sessions and continue until Final Acceptance of the Works. Thai counterpart staff will be designated for this purpose. Salaries, overtime pay and cost of living allowances of these counterpart staff will not be the responsibility of the CONTRACTOR, but the CONTRACTOR shall be fully responsible for providing all necessary instructions, manuals and tools, and for all other non salary related costs. The Tenderer shall specify the equipment, tools and other items to be provided in his Tender.

7.0 DOCUMENTATION

7.1 GENERAL

The documentation shall contain complete details of how the system was actually built, and how it works, together with complete operating and maintenance information. The documentation shall consist of the following manuals and drawings:

(a) System design manual
(b) Operator's manual
(c) Software manual
(d) Hardware manual
(e) Maintenance manual
(f) Program listing
(g) As-built drawings

The documentation shall be a detailed presentation with text and illustrations. All documentation shall be in English and shall be subject to the approval by the ENGINEER.

The documentation process shall include the preparation, editing, submittal for approval, publication, delivery and acceptance of the documentation in accordance with the requirements of the Contract.

7.2 PRESENTATION OF DOCUMENTATION

All documentation shall be prepared in a clear, concise manner with appropriate illustrations. Except otherwise specified by the ENGINEER, all documentation except drawings shall be prepared on A4 size sheets. All documentation shall carry an issue number, revision number and date. A uniform style and format shall be followed as much as possible.

Ten (10) copies of all documentation, manuals and drawings of as-built conditions shall be submitted. In addition one set of reproducible drawings of as-built conditions shall be submitted.

In order to maintain liaison between the CONTRACTOR and the ENGINEER, documentation concerning each part of the Contract shall be produced as part of each component job and not left until the preparation of the final manuals. Effort may be saved, and familiarity with the presentation of information will be maintained by writing the

documentation during the Contract in a form suitable for inclusion in the relevant final manuals.

All system manuals shall be available at the beginning of the classroom training. Re-issues shall be provided if site commissioning and testing makes this necessary.

If changes or modifications are required in any of the documents previously submitted, the CONTRACTOR shall fully describe the changes or modifications, and immediately submit them to the ENGINEER for approval.

7.3 STANDARD DOCUMENTATION

Standard documentation shall be provided for the computer and peripherals (hardware and software), programming manuals including the languages to be used, transmission equipment, CCTV system, air conditioner, power supplies, and other standard products to be supplied under the Contract.

7.4 SYSTEM DESIGN MANUAL

The intent of the system design manual is to give an overall description of the Area Traffic Control System and the CCTV system supplied under the Contract. The manual may be divided into sections to cover all and every aspect of the system. The description shall be plain and the detail of operation shall be left to other manuals with adequate reference to them. The manual should provide cross references to the appropriate manuals of the System when necessary to do so.

The system manual shall completely define all functions, inputs, outputs including methods of entering inputs, methods of obtaining outputs, data content, format, sequence, and timing. The system structure and organization shall be described including all the data flow paths through the System and all the data files in the System. This description shall clearly present the functional relationship of the computer programs with one another and with all peripheral, CRT display panel, control desks, central controllers, transmission equipment, detector, or other equipment. An overall system flow diagram shall be provided.

7.5 OPERATOR'S MANUAL

This manual shall comprise a concise set of procedures the computer system operator may require to operate the System with a minimum of detailed technical description of the internal working of the various parts of the System. Cross references to the appropriate manuals for detailed technical descriptions however shall be provided.

The manual shall list specific procedures to be followed for both hardware and software operations, which may have to be followed either by programmers or hardware engineers. Instructions shall therefore be basic and detailed. A step-by-step procedure shall be given for switching on and off power, controlling the equipment and for starting up and shutting down the System. This shall include calling down, or loading the operating programs, checking that they are running correctly, operation of desks for traffic signals, CCTV cameras and monitors, CRT display panel, traffic congestion status indication wall map, and use of utility programs through keyboard and CRT display.

In addition to the routine operation, procedures shall be given for fault diagnosis. Typical symptoms shall be listed, with corresponding corrective or emergency action to be taken.

7.6 SOFTWARE MANUAL

The software manual shall be project oriented. The software manual shall therefore include the application programs and data files.

7.6.1 STRUCTURE

The manual shall describe the overall software structure with particular attention to the points at which further user programs can be interfaced. It is essential that the relationship of programs and their calling sequences are explained in such a manner that it may be clearly understood, especially by any competent programmer who wishes to specify or interface a new program into the system.

7.6.2 PROGRAM LOGIC/FUNCTION

Operational objectives for each program shall be described. All logic and transformations on the input data in order to generate output data and accomplish system functions shall be described, together with their interaction, sequencing and time requirements. Derivations of any mathematical equations shall be stated.

7.6.3 FLOWCHARTS

Each major section of the programming logic as described above shall be presented in greater details. The details shall be developed into a format of flowcharts or other graphical methods using statement and decision blocks to show the flow of information. Within each statement and decision block sufficient information shall be presented to describe what is being accomplished. Mathematical or engineering terminology and equations shall be incorporated when necessary to fully describe the operations to be performed.

7.6.4 OUTPUT FORMATS

Sample output formats shall be provided from actual printer output and CRT display outputs with explanation for each item on the output format.

7.6.5 MEMORY MAP

A map of the main memory of the CPU shall be provided to show the numbered locations of the main memory and the information stored in each location.

For disk storage device, a map of the device shall also be supplied. It shall show the memory location and the information stored in these locations.

7.6.6 DATA FILE

The format of all data structures shall be given together with the contents of constant files.

7.7 HARDWARE MANUAL

This manual shall provide a complete description of the hardware of all the System equipment and components. Documents regarding CCTV, vehicle detectors, traffic signals, and communication systems equipment shall be bound in separate volumes for convenience of use.

The following information shall be provided for each applicable equipment item or component:

(a) FUNCTIONAL DESCRIPTIONS

All information necessary to fully explain the basic function or use of the equipment shall be provided. It shall include a block diagram presentation of the equipment.

(b) OPERATING PROCEDURE
The operating procedure shall be fully described in a simple, clear language. Appropriate illustrations shall be provided.

A list of applicable test instruments, and tools required to perform necessary measurements shall be included. Setup tests and calibration procedures shall also be described if applicable.

7.8 MAINTENANCE MANUAL

This manual shall describe both preventive and corrective maintenance procedures in such detail that maintenance personnel can perform the proper maintenance work by reading this manual.

7.8.1 PREVENTIVE MAINTENANCE

The manufacturer's recommended procedures for proper preventive maintenance shall be indicated to ensure reliable equipment operation. Specifications including defined tolerances for all electrical, mechanical and other applicable measurements and adjustments shall be listed. Periodical repainting servicing shall also be described.

7.8.2 CORRECTIVE MAINTENANCE

This section shall provide the information necessary for isolation and repair of failure and malfunctions. Accuracies, limitations and tolerances for all electrical, physical and other applicable measurements shall be described. Instructions for disassembly, overhaul and reassembly, including workshop performance requirements shall be provided.

Fully detailed step-by-step instructions shall be given where a failure to follow special procedures would result in danger to operating or maintenance personnel, damage to the equipment, improper operation, etc. Instructions and specifications shall be included for such maintenance work that may be accomplished by specialized technicians and engineers in a modern electro-mechanical workshop. Instructions concerning special test set-up, component fabrication, use of special tools, jigs and test equipment shall be included.

Maintenance procedures shall cover the diagnosis of faults, testing and setting up adjustments, replacements of units and operation of test equipment.

7.9 AS-BUILT DRAWINGS FOR WHOLE WORKS

The CONTRACTOR shall submit ten (10) copies of as-built plans and drawings, and a set of reproducible positive as-built plans and drawings of Works to the ENGINEER within reasonable time after the Tests on Completion for the Whole Works but not later than six (6) months prior to the issuance of the Acceptance Certificate. As-built plans and drawings to be submitted by the CONTRACTOR shall include but not be limited to:

(a) detail drawings of all equipment,
(b) signal pole, detector pole, etc. (civil structure plans and drawings)
(c) communication network conductor schedule,
(d) communication network layout,
(e) signal installation diagram at each intersection including phase step diagram,
(f) typical timing plans along routes,
(g) detector location layout,
(h) TCC control room and CPU room layout,
(i) Power supply room and generator room layout.

These plans and drawings shall incorporate changes made during the installation and training. A uniform legend shall be used throughout the documentation. The CONTRACTOR may duplicate the original copies of plans and drawings prepared by the BMA and make "second" original copies of the plans and drawings. Then, necessary modifications may be made on the "second" original copies of the plans and drawings.

7.10 PROGRAM LISTING

A complete and fully debugged and assembled listing of all traffic control application programs shall be required. This requirement does not include the listing of operating systems and other standard software supplied by commercial software developers.

The listings shall contain as many comments as possible.

7.11 PROGRAMS ON MAGNETIC TAPE

As part of the documentation, the CONTRACTOR shall provide a copy of all source programs which have been coded for this System on a magnetic tape(s) ready for compilation. The source programs shall be compatible with the flowcharts and program listings. In addition, a copy

of the operating system, utility programs and other programs used in the CPU shall be provided on a magnetic tape(s) which can be readily loaded.

8.0 POWER SUPPLY

8.1 PROCEDURE

The BMA shall perform all the necessary application procedures to the Metropolitan Electricity Authority (MEA) required for the power to be supplied to the Traffic Control Center Site and terminal equipment. All the expenses charged by MEA regarding such applications shall be borne by the BMA. The work to be undertaken by MEA up to the boundary of property and responsibility between the BMA and MEA, as well as the expenses incurred therefrom, shall be outside the scope of this Contract.

The Clause does not apply to the electricity needed for the execution of the Works (See Section 11.23, "Supply of Water and Electric Power" of the General Conditions of Contract).

8.2 RESPONSIBILITY BOUNDARY

The property and responsibility boundary with respect to the power supply facilities of MEA and the power receiving facilities of the BMA shall be the primary side of the switch installed adjacent to the lead-in pole to be erected by the CONTRACTOR for the BMA.

The CONTRACTOR shall submit to the ENGINEER for prior approval planned drawings for the power supply construction work and their methods between the property and responsibility boundary with MEA or the distribution facilities and the point where the power is required.

9.0 TOT LINES

9.1 PROCEDURE

The BMA shall perform all the necessary application procedures to the Telephone Organization of Thailand (TOT) required for leasing and installing telephone lines to the Traffic Control Center and terminal equipment. All the expenses charged by TOT regarding such applications shall be borne by the BMA. The work to be undertaken by TOT up to the boundary of property and responsibility between the BMA and TOT, as well as the expenses incurred therefrom, shall be outside the scope of this Contract.

9.2 RESPONSIBILITY BOUNDARY

The property and responsibility boundary with respect to the telephone lines of TOT shall be the primary side of the fuse board erected by the CONTRACTOR for the BMA.

The CONTRACTOR shall submit to the ENGINEER for prior approval planned drawings for the communication cables and their methods between the property and responsibility boundary with TOT.

10.0 TRAFFIC ENGINEERING IMPROVEMENTS

The CONTRACTOR will not be required to carry out such works as geometric improvements of the intersections to be signalized, and installation of pavement markings and traffic signs at or in the vicinity of the intersections in this Contract. The Traffic Engineering Division of the BMA will be responsible for carrying out these works prior to the installation of cables, signal and other terminal equipment under this Contract. The CONTRACTOR shall however be fully responsible for restoration works of the above facilities as stipulated in section 5.5.

The CONTRACTOR shall submit to the ENGINEER a planned time schedule for installation works of terminal equipment and their associated civil works at each intersection to be signalized in order to enable the BMA to schedule the availability of resources, personnel, etc..

11.0 SPARES, CONSUMABLES AND MAINTENANCE EQUIPMENT

11.1 GENERAL

The CONTRACTOR shall furnish specific spare parts, consumables, and maintenance equipment as indicated in the Tender Schedule.

11.2 RECOMMENDED SPARE PARTS AND MAINTENANCE EQUIPMENT

The Tenderer shall provide in his Technical Proposal detailed information on spare parts and consumables necessary for the continuous operation and maintenance of the equipment to be installed under this Contract through the guarantee period and two (2) additional years following system acceptance. The information shall include identification, source of supply, and availability for the next 10 years. Recommended quantities for 2 years of maintenance, proposed rates and total prices for these spare parts and consumables shall be listed in "Proposed Rates and Prices of Recommended Spare Parts and Maintenance Equipment" using the sample form provided in PART B of Invitation to Tender. The spare parts and consumables shall be separately listed for the traffic control and the CCTV systems.

The Tenderer shall also identify maintenance equipment, tools, testers, and measuring apparatus which will be required to effectively maintain the ATC system and provide all necessary detail in his Technical Proposal. The costs of furnishing these equipment shall be quoted in the "Proposed Rates and Prices of Recommended Spare Parts and Maintenance Equipment." The recommended maintenance equipment should include, among others, the following:

(a) Portable cable Checker
(b) Merger, 250 VDC and 500 VDC
(c) Detector checker
(d) Portable emergency power supply unit (220 V, 1 KVA) which can be install on a maintenance vehicle
(e) Drainage pump
(f) Concrete cutter
(g) FEP Tester
(h) Local controller simulator
(i) PROM writer with software

The BMA reserves the option to require the CONTRACTOR to furnish any or all of the recommended spare parts, consumables, and maintenance equipment.

11.3 PARTS SUPPLY GUARANTEE

The CONTRACTOR, his legitimate successor or his designate, shall guarantee for a period of ten (10) years after the Taking-over of the Works that he will supply promptly upon the written request from the BMA any parts, components or equipment incorporated in the System. This Clause shall not necessarily be construed to read that the CONTRACTOR be required to maintain the inventory to cover the entire items for anticipated requirement for such purpose through the 10 years' period. Because of discontinuation of production of such particular items or because of any reasons beyond his control, if the CONTRACTOR fails to supply the requested parts, components or equipment, he shall satisfy the need of the BMA by whatever appropriate substitutes available with consent and approval of the BMA, but always in such a manner and outcome that the substitutes can maintain or improve the Works' performance or capabilities as a whole.

The CONTRACTOR shall be paid for such supply duly made at such costs as he shall charge to his domestic customers on similar occasions at the time plus freight, insurance, handling charge and other related expense actually paid.

11.4 MAINTENANCE VEHICLES

The CONTRACTOR shall be responsible for furnishing two small size van for the purpose of maintenance work. The vans shall be of at least 1500cc vehicles each equipped with a maintenance local controller identical to those supplied and installed, and a power generator.

The maintenance local controller shall be capable of operating the signal when it is connected to the maintenance connector plug which is located in the local controller cabinet (see section 13.11.6).

The maintenance van shall also be equipped with racks and compartments properly organized to keep an inventory of spare parts, and tools for maintenance work.

11.5 MAINTENANCE DATA PROCESSORS

The CONTRACTOR shall furnish two (2) desk-top microcomputer systems for maintenance data processing. The system shall conform to the following:

(a) IBM PC compatible with 32-bit processor, IMB RAM
(b) Color CRT, VGA graphic
(c) Full size keyboard
(d) One (1) 5-inch and one (1) 3.5-inch floppy disk drives
(e) One (1) 40 MB harddisk with autopark.
(f) One 24-pin dot matrix printer with 48 KB buffer, 15-inch paper and capable of both cut sheet feeding and continuous paper feeding. Print speed shall be 90 CPS in letter quality mode.

The latest version of MS-DOS operating system software and corresponding manuals shall be provided.

12.0 TECHNICAL PROPOSAL

The Tenderers shall describe the proposed works in sufficient detail in his Technical Proposal to enable the BMA to evaluate the technical adequacy of the proposed system. The Technical Proposal shall include the statement of compliance with the Specifications indicating whether the proposed equipment comply with the specified requirements. If the proposed system does not comply with the Specifications, the details of differences shall be described together with the alternative features or facilities offered.

If the Tenderer wishes, an alternative may be proposed, insofar as it is advantageous to the BMA either functionally or economically in the opinion of the Tenderer. However, the BMA reserves the right to accept or reject such alternative proposal.

The Technical Proposal shall be written in the same sequence as the Specifications. Where the supporting documents are provided, a cross reference shall be prepared. The Technical Proposal shall be written in English.

The Technical Proposal shall include the description of system as a whole and equipment comprising the system. The description shall include how the requirements of the Specifications are achieved. If necessary, block diagram, flowchart, timing chart or other explanatory documents shall be attached.

Equipment comprising the system shall be defined. For each equipment, the following items shall be stated:

(a) Electrical and/or mechanical specifications
(b) Interface with other equipment
(c) Capacity
(d) Environmental conditions
(e) Physical dimensions
(f) Operation console layout
(g) Brand, model, and/or type
(h) Catalogue, brochure, or other supporting document (if any)

DIVISION II : TRAFFIC SIGNAL SYSTEM

DIVISION II : TRAFFIC SIGNAL SYSTEM

1.0 GENERAL REQUIREMENTS

1.1 GENERAL

Furnishing and installing traffic signal system shall conform to established industry standards and these specifications.

It shall be the responsibility of the CONTRACTOR to furnish, install, and deliver a complete functional area-wide traffic signal control system capable of unattended 24 hours a day, 7 days a week operation. The traffic signal system shall encompass the entire Stage I area of the Bangkok Area Traffic Control Project and shall include, among others, the following:

(a) Central traffic control and man-machine interface equipment and software.
(b) Local intersection and pedestrian crossing signal equipment and software.
(c) System control, traffic count, and actuation control detectors.
(d) Communication cables and equipment.
(e) Control Center furnishing and accommodations, including an emergency power supply system.

1.2 EXISTING SYSTEM

An area-wide signal control system consisting of 47 intersections exists in the area within the downtown of Bangkok. The system is currently controlled by a small micro-processor installed in the Ministry of the Interior (MOI). This system will be abandoned and the 47 intersection signals are to be controlled by the new ATC system to be installed under this Contract. Also to be included in the new ATC system are 83 existing signals (including 3 pedestrian signals) which are operating in an isolated mode.

All existing local controllers will have to be replaced to ensure compatibility with the new ATC system. Modifications and/or addition to existing signal display equipment and some wiring changes at the intersections will also be necessary to meet new phasing requirements and to improve the visibility of the signals.

The CONTRACTOR shall modify the existing signals as specified herein and as indicated on the Plans.

1.3 FUTURE EXPANSION

The central traffic control system shall be capable of controlling up to 400 signals and 1,600 detectors. Other than installing additional front-end processors if necessary, and communication equipment, and expanding the data base, bringing future signals on line shall not require additional hardware or software modifications of the central computer system (modifications to certain man-machine interface equipment such as wall maps and wiring may be necessary).

1.4 SYSTEM CONTROL AND OPERATION

The ATC system shall contain the following functional components:

(a) Area wide signal control
(b) Data gathering and processing
(c) Equipment monitoring
(d) Man-machine interface
(e) Data recording and reporting

1.4.1 AREA WIDE SIGNAL CONTROL

The ATC system shall be capable of coordinated as well as isolated control of all of the signals in the Project. It shall be capable of coordinated control on a real-time basis from the control center based on current traffic flow data obtained from vehicle detectors (traffic responsive control). The traffic responsive control shall be adoptive to all traffic flow conditions ranging from under-saturation to over-saturation. The system shall also provide signal control on a time-of-day basis if so specified and as backup for the traffic responsive control.

The central traffic control system shall use a multi-processor, hierarchical computer system to ensure a high level of system reliability. The system shall be capable of multi-level fail-safe modes of operation which can continue to provide the highest level of signal control possible under various equipment failure conditions.

It shall be possible to operate the signals manually on site in case of emergency conditions.

1.4.2 TRAFFIC DATA GATHERING AND PROCESSING

The ATC system shall be capable of gathering traffic related information by means of vehicle detectors, public telephones, fax devices, and wireless radio system managed by the BMA and the police department. Installation of a wireless radio system is not included in

this Contract, but spaces shall be reserved in the control console for the system.

Detector data, including volume and occupancy, shall be transmitted to the central computer system for control, monitoring, and statistical data compilation purposes.

1.4.3 EQUIPMENT MONITORING

The system shall be capable of monitoring the conditions of all major central and field equipments at all times and detecting and reporting their failure immediately and automatically.

1.4.4 MAN-MACHINE INTERFACE

The ATC system shall include man-machine interface equipment capable of providing, as a minimum, the following functions:

(a) Signal Control

1. Pickup and drop-off of signals
2. Modification of control mode
3. Modification of control area configurations (cycle subarea, key/ordinary intersections)
4. Modification of phasing plans
5. Modification of timing parameters and timing plans
6. Modification of traffic responsive timing plan selection parameters and threshold values
7. Modification of detector function assignments
8. Modification of various threshold values, weighing factor, and adjustment factors for detector data processing, detector check, congestion status determination, etc.
9. Enabling local manual control of signals
10. Upload and download of traffic control data to and from local controller

(b) Information Display

1. Requesting and controlling display of congestion level, controller status, detector status, phase 1 green, and other information available on the wall maps.
2. Requesting display and/or obtaining hardcopy printout of traffic data, control status and parameters, equipment status, and other database data available through the CRT terminals of work stations.

1.4.5 DATA RECORDING AND REPORTING

The ATC system shall keep permanent records of detector data, operation status, manual intervention activities, and equipment failure history for future references and analysis purposes. The data shall be recorded in sufficient detail to reconstruct the actual events as they occurred.

1.5 SYSTEM CONFIGURATION

A simplified block diagram showing major components of the ATC system is given on Plan No.1202.

1.5.1 CENTRAL COMPUTER SYSTEM

It is required that the central traffic control system employ a hierarchical computer system consisting of a central, high level, computer (CPU) and several lower level front-end processors (FEP). To ensure a high level of reliability, it is also required that the central computer and each of the front-end processors be of a dual-processor design with one main processor and one standby processor. In the event of main processor failure, the standby processor shall be automatically switched into operation.

1.5.2 MAN-MACHINE INTERFACE

Man-machine interface functions shall be provided through two (2) wall maps and three (3) sets of computer work stations.

Two of the work stations will be located in the control room and will be used mainly for control purposes. The third work station will be located in the equipment room and will be used mainly for monitoring of equipment status for maintenance purposes. However, it shall be possible to use the work stations in parallel to perform any of the functions assigned to them.

One of the wall maps shall be used to display signal operation and traffic flow conditions for control and operational purposes. The other wall map shall display equipment status and failure conditions for maintenance purposes.

1.5.3 COMMUNICATION SYSTEM

Communication between field and central equipments shall be through a leased TOT cable network (wiring and terminal equipment to connect to the TOT network will be required).

2.0 AREA WIDE SIGNAL CONTROL OPERATIONS

2.1 GENERAL

Area wide signal control operations of the ATC system shall conform to the functional requirements and operational procedures described in this section. The descriptions are general in nature and are intended to indicate the overall operation and traffic control methods of the system which will be required to provide effective control of the signals. It shall be the responsibility of the CONTRACTOR to develop any additional procedures, algorithms, and detailed software structure necessary to complete the system design. Such details as may be required to clearly describe the Tenderer's proposed system shall be provided in his Technical Proposal.

If the Tenderer wishes to propose alternative methods of signal control and techniques which do not conform to the requirements of this section, he shall explain in sufficient detail in his Technical Proposal to show that the proposed methods are equal to or better than what have been described in these specifications.

2.2 OPERATION STATUS AND MODE OF CONTROL

Operation of each and every signal in the system shall normally be under the control or supervision of the central computer system. However, the signal may also be operating independently of the central computer under local automatic or manual modes of control.

For the purpose of describing the required operations of the ATC system, a signal will be said to be operating under one of the following status:

(a) On-line (or central computer control)
(b) Standby
(c) Off-line (or local control)

Under each operating status, one or several modes of control shall be possible as follows:

(a) Under On-line Status
    1. Traffic responsive control (or normal central control)
    2. Time-of-day control

(b) Under Standby status
    1. Local Time-of-day control

2. Local Isolated control
3. Manual control
4. Flashing
5. Lantern-off

(c) Under Off-line Status
1. Local Time-of-day control
2. Local Isolated control
3. Fail-safe Fixed-time control
4. Manual control
5. Flashing
6. Lantern-off

Where actuation detectors are installed, the local controller shall execute the actuation timing control under all automatic modes of control except when it is operating in the fail-safe fixed-time mode. The requirements for actuation control are described under "Local Controller" section of these specifications.

2.2.1 ON-LINE (OR CENTRAL COMPUTER) CONTROL

When a signal is on-line (or under central computer) control, the local controller receives commands from the central computer system and execute control mode and signal timing accordingly.

Under central computer control, the signal shall normally operate in either the traffic responsive mode or the time-of-day mode of control according to a pre-stored schedule of control mode selection. However, it shall be possible to specify local isolated mode of control in the mode selection schedule (i.e. temporarily put a signal in the standby mode). It shall also be possible for the operator to override the mode selection schedule and change the control mode at any time. It shall be possible to schedule the mode of control on a time-of-day basis for each day of the week separately to be stored for automatic execution.

The actual executed timing plans for each day and their times of implementation shall be memorized in the central computer system. At the end of each day, if an intersection is operating normally under the control of the central computer system, the stored timing plans and schedule in the FEP shall be updated according to the day's actual executed timing plans and their times of execution. The process shall use, for example exponential smoothing, to produce updated cycle lengths and splits, subject to normal constraints such as minimum green, pedestrian interval, cycle length increment, and minimum plan change

interval. The current day's offsets shall become the updated offsets since offsets are selected on a time-of-day basis even under traffic responsive mode of control. The newly updated daily timing plans and schedule shall be converted to local controller time-of-day timing plans and downloaded to the local controller to update the local timing database.

The requirements for traffic responsive control and time-of-day control are described under "Normal Central Control" and "Time-of-Day Control" sections, respectively, of these specifications.

2.2.2 STANDBY

Under the status of standby operation, the communication link between the local controller and the central computer remains fully functional but the signal is under the automatic control of the local controller independently of the central computer system. The signal may operate under any one of the possible modes of control but the central computer system can pick it up (i.e. return the signal to on-line) at any time.

When a signal is turned on initially, it should be in the standby status operating in the isolated mode. A signal can also be put into a standby status by the central computer or by the operator.

2.2.3 LOCAL TIME-OF-DAY CONTROL

Under the local time-of-day mode of control, the signal is operating under the direct control of the local controller. The signal is executing coordinated timing plans on a time-of-day basis using timing plans stored in the local controller, subject to pre-emption calls and actuated control if applicable.

When the central equipment or communication between the local controller and the central computer is disabled due to an equipment failure, the signal shall operate under local time-of-day control.

It shall also be possible for the operator to put a signal in this mode of control at any time from the control center. In this case, the signal shall be returned to central computer control only by manual pickup.

The requirements for local time-of-day control are described under "Time-of-Day Control" and "Local Controller" sections of these specifications.

2.2.4 LOCAL ISOLATED CONTROL

Under local isolated mode of control, the signal is operating independently of other signals without any form of coordination. The signal shall operate on the basis of an isolated timing parameter set which is stored in the local controller.

A signal may be placed under the local isolated mode by the central computer system on a time-of-day basis, by operator intervention, or when the local time-of-day mode of control is disabled due to an equipment failure.

2.2.5 FAIL-SAFE FIXED TIME CONTROL

For fail-safe operation in the event of microprocessor failure or failure in RAM, the controller shall be provided with the capability to control the signal using a fixed-time timing plan which is stored in a ROM and can be executed directly by a special LSI circuit.

2.2.6 MANUAL CONTROL

Under the manual mode of control, the signal is controlled manually at the intersection through the use of manual control buttons located on the Police panel of the local controller.

Under normal conditions, manual control of the signal shall be possible only if it is enabled from the control center by the control center operator. It shall be possible to operate the signal manually if it is dropped off-line due to an equipment failure even if the manual control is not already enabled. However, as soon as on-line control is possible, the signal shall be picked up automatically if the manual control has not been enabled.

2.2.7 FLASHING

It shall be possible to set the signal in the flashing mode from any one of the following:

(a) From a local controller switch manually.
(b) From the control center either by the central computer system on a time-of-day basis or by the operator.
(c) From the local controller automatically on a time-of-day basis as part of the local time-of-day mode of control.

The requirements of 2.2.4 Local Isolated Control, 2.2.5 Fail-Safe Fixed Time Control, 2.2.6 Manual Control and 2.2.7 Flashing are described under "Local Controller" section of these specifications.

2.3 TIMING PARAMETERS AND TIMING PLAN

2.3.1 FOR COORDINATED CONTROL

For the purpose of these specifications, cycle, split, offset, and phase sequence within the context of coordinated control will be referred to as timing parameters and a data set containing several cycle, split, and offset values and phase sequences will be referred to as a timing parameter set. A typical timing parameter set shall contain at least 7 cycle, 7 offset, and 7 split values and 4 phase sequences. A unique combination of cycle, split, offset, and phase sequence constitutes a timing plan. Several timing plans together with a daily schedule of implementing them will be referred to as a time-of-day timing plan.

To insure consistency in the specification and selection of cycle, split, offset, and phase sequence, linking of the parameters will be necessary. The Tenderer shall provide details of his proposed timing parameter/timing plan structure in his Technical Proposal. In the traffic control software, it shall be required that all additions and changes in the timing parameters and timing plans be subjected to a rigorous routine of consistency check before the database is permanently altered.

The ATC system shall contain pre-stored timing parameter sets from which timing plans can be generated on a time-of-day basis or dynamically in response to traffic flow conditions on a traffic responsive basis but changes in phase sequence and offset shall be done on a time-of-day basis only.

Under traffic responsive mode of control, split values may also be generated on a real time basis based on current traffic flow data.

2.3.2 FOR ISOLATED CONTROL

When a signal is operating independently of other signals (isolated), controlling factors particularly the maximum and minimum or fixed durations of each display interval will be referred to as timing parameters. Phase sequences may be included in the timing parameter set and be selected on a time-of-day basis.

2.4 GROUPING OF INTERSECTIONS

2.4.1 CYCLE SUBAREAS

For the purpose of timing plan selection, the intersections shall be grouped into cycle subareas.

Cycle Subarea -- A cycle subarea shall contain a group of signals which shall operate on a common cycle length under either traffic responsive or time-of-day mode of control. A cycle subarea may contain from one to 16 intersections.

It shall be possible to define up to 100 subareas and assign any of the signals in the system to any of the subareas.

It shall be possible to operate any of the signals in a cycle subarea with 1/2 cycle length and maintain offset coordination every other cycles.

A preliminary cycle subarea plan is included in Plan No. 1203. Final groupings shall be developed by the CONTRACTOR during system design.

2.4.2 KEY AND ORDINARY INTERSECTIONS

For the purpose of cycle by cycle split adjustments, the CONTRACTOR shall designate an intersection as either a key intersection or an ordinary intersection and state his method of designating it. Congestion detectors will be installed for key intersection approaches and the need to execute split adjustment will be based on congestion level of key intersections. Split control for ordinary intersections shall be dependent on the splits of nearby key intersections.

2.5 NORMAL CENTRAL CONTROL

The normal central control (or traffic responsive mode of control) shall operate on the basis of a cycle time selection process and a split adjustment process, both to be executed in response to real-time traffic flow conditions. Offset selection shall be made on a time-of-day basis.

2.5.1 CYCLE TIME SELECTION

The cycle time selection process shall be executed every cycle or such every number of cycles as may be specified in the system database which shall be operator-defined and can be modified at any time through the work station, and shall use the occupancy data from designated detectors to select the most appropriate cycle time for

implementation. Once a cycle time is implemented, it shall remain in force for a period of at least 15 minutes or such other time period as may be specified in the system database which shall be operator-defined and can be modified at any time through the work station, except when it is interrupted by manual override or railroad pre-emption.

The logic for determining the most appropriate cycle length may be explained as follows:

(1) For subarea which includes key intersection(s)

1. For a key intersection, the critical movement in each phase of a cycle is found based on occupancy data from designated detectors.

2. The saturation degree at the key intersection is calculated by adding the occupancy values for all the critical movements.

3. The same procedure is used to determine saturation degree at other key intersections in the subarea.

4. The intersection with the highest saturation degree is chosen.

5. The cycle length in the subarea is determined from a pre-stored table for the intersection, corresponding to the saturation degree.

(2) For subarea which does not include any key intersection

1. If the subarea contains intersection with detectors installed at all its approaches, the procedure for determining the cycle length shall follow that for subarea having key intersection(s).

2. In case of subarea where there is no intersection with detectors at all the approaches, the cycle length shall be decided from the pre-stored table, and shall correspond to the largest occupancy value among values obtained from all the system detectors in the subarea.

2.5.2 SPLIT ADJUSTMENT

For key intersections where over-saturation is likely to occur, the split shall be adjusted on a cycle by cycle basis.

The split adjustment process shall be allowed only if the intersection is properly instrumented with queue detectors and all queue detectors are functioning properly.

Split adjustment for key intersections shall be done when one approach of the intersection is more congested than another approach which is on a different phase. The amount of green time for the more congested approach shall be increased and that of the less congested approach shall be decreased. The amount of adjustment may be a constant number of seconds or a constant percent of the cycle. This adjustment factor shall be easily changed from the work station and it shall be possible to assign different adjustment factors for different key intersections.

Split adjustment for an ordinary intersection shall be linked to the split of its associated key intersection. No cycle by cycle split adjustment will be required for ordinary intersections.

The Tenderer shall describe in detail his split adjustment algorithm, including flow charts and required detector data processing in the Technical Proposal.

2.5.3 OFFSET SELECTION ON TIME-OF-DAY BASIS

Offset selection for key intersections as well as ordinary intersections shall be made on a time-of-day basis. In developing the time-of-day offset table, the CONTRACTOR shall take into consideration variations in the congestion level throughout the day. During periods of over-saturation, offsets shall be designed to maximize the number of vehicles stored in the queue and to avoid blockage of intersections by queues extending from downstream intersections.

2.5.4 COORDINATION BETWEEN CYCLE SUBAREAS

Under the traffic responsive mode of control, if the selected cycle lengths for adjacent subareas are within 10 seconds to each other, or such other value as may be specified in the system database which shall be changeable by the operator through the work station, a procedure shall be provided to adjust the cycles so that a common cycle length is used and coordination between the subareas is maintained.

2.5.5 MINIMUM REQUIREMENTS

The CONTRACTOR shall be responsible for developing the necessary software meeting the following requirements:

(a) It shall be possible to define the detectors assigned to the key intersections, the split adjustment factor, the limit of split adjustment through entries on CRT parameter edit screens.

(b) It shall be possible for the operator to enable or disable the split adjustment process for a particular signal without removing the signal from the list of eligible signals or changing any other control parameters.

(c) It shall be possible to display on CRT continuously updated cycle by cycle or minute by minute, for fifteen (15) or more consecutive time periods, occupancy, and queue status data for an operator-selected key intersection signal. The CONTRACTOR shall indicate his proposed display in his technical proposal.

(d) It shall be possible to produce a hard copy of any of the CRT displays on command or alternatively produce a report containing all relevant parameter settings and queue status information.

(e) The split adjustment process for an eligible intersection shall be automatically discontinued if any of the detectors assigned to that intersection is judged to be marginal or unacceptable.

2.6 TIME-OF-DAY CONTROL

2.6.1 CENTRAL TIME-OF-DAY CONTROL

When the signal is under the control of the central computer system, the time-of-day mode of control shall be implemented by the front-end processor (FEP) when specified in the time-of-day mode selection table or directed by the operator, or when both CPU's (main and standby CPU) are inoperative. The timing plans shall be stored in the FEP and shall meet or exceed the following requirements:

(a) It shall be possible to specify 20 or more timing plans for each signal and for each day.

(b) It shall be possible to schedule the timing plans for each day of the week and 3 other special days separately (i.e. 10 days of timing plans).

(c) It shall be possible to change timing plans at least 20 times a day with the shortest time period being 15 minutes.

(d) It shall be possible to include local isolated mode of control, flashing, and lantern-off in the daily schedule.

2.6.2 LOCAL TIME-OF-DAY CONTROL

When the signal is dropped off-line due to an equipment failure, the signal shall normally operate in the time-of-day mode by the local controller using locally stored timing plans. The local time-of-day control shall include offset coordination without instructions from the central computer system, using the local clock equipped in a local controller.

The local controller shall have the capability to store at least 20 timing plans and 4 daily timing plan schedules which can change timing plan at least 20 times a day. The local controller stored time-of-day timing plans and schedules shall be updated daily (by the central computer system) based on a learning process which is executed when the controller is under the control of the central computer system.

The learning process and the corresponding timing plan database structure shall be proposed by the CONTRACTOR and submitted to the ENGINEER for approval. The database structure and the learning process shall conform in general to the following:

(a) Each timing plan shall be in effect for a period of 30 minutes or longer.

(b) It shall be possible to change timing plan every 30 minutes during AM and PM peak periods (each period shall be at least 2 hours).

(c) The method of dividing the 24-hour day into timing plan change periods may be done automatically using an internal logic or by operator input.

(d) There shall be at least one timing plan schedule for weekday, one schedule for Saturday, one schedule for Sunday, and one schedule for a special event day.

(e) For each timing plan change period, the last normal day's timing plans used during that period shall be examined and the most frequently used plan (i.e. plan used for the longest time period) shall be stored. In the case of equal frequency of use, the shorter cycle length plan shall prevail.

(f) A normal day shall be defined as a day when no manual control and no operator intervention occurred, and the signal is on-line for the entire 24-hour period.

3.0 TRAFFIC DATA GATHERING AND PROCESSING

3.1 GENERAL

The ATC system shall be provided with traffic data gathering and processing capabilities necessary for traffic responsive control, congestion and flow level monitoring, historical traffic flow data gathering and actuated control.

For the purpose of these specifications, detectors which are used for local actuated control will be referred to as actuation detectors and those for all other purposes will be referred to as system detectors. However, it shall be possible to use actuation detector for system detector purposes. Also, it shall be possible to use a system detector for any and all of the purposes.

Presence of vehicles shall be detected by loop or ultrasonic vehicle detectors, compiled into volume and occupancy counts in the field by a pre-processor, and then transmitted to the central computer system and/or local controllers as required.

3.2 DETECTOR DATA PRE-PROCESSOR

The CONTRACTOR shall furnish and install a detector data pre-processor in each detector cabinet and each local controller cabinet where at least one detector is connected to. The pre-processor may be a stand-alone unit or may be designed as an integral part of the local controller.

The pre-processor shall compile and accumulate volume and occupancy counts for each detector and transmit the data to the central computer system. It shall be possible to connect up to 8 vehicle detectors to each pre-processor.

It may be necessary to connect an actuation detector to a pre-processor as well as directly to the local controller to meet the requirements of actuation control and detector data testing.

3.2.1 DETECTOR DATA COMPILATION AND ACCUMULATION

The pre-processor shall sample the presence of vehicles from the loop or ultrasonic detector and compile them into volume and occupancy counts. For each detector, the volume and occupancy counts shall be accumulated continuously using two counters each with a capacity of at least 4 digits.

3.2.2 DATA TRANSMISSION

For each detector, the volume and occupancy counts in the pre-processor shall be transmitted every 5 minutes to the central computer automatically. The volume and occupancy counts shall also be transmitted immediately whenever a command signal to transmit is received from the central computer.

3.3 DETECTOR DATA PROCESSING IN CENTRAL COMPUTER

After receiving the volume and occupancy counts from the pre-processor, the central computer system shall calculate 5-minute volume and occupancy, check the data for reliability, compute smoothed 5-minute volume and occupancy, compute congestion indices or other traffic flow parameters and use them for traffic responsive control, traffic flow monitoring, compilation of statistical data, and detector malfunction monitoring.

For split and offset adjustments of key intersections under near- and over-saturated conditions, cycle by cycle volume and occupancy of specified detectors shall be calculated in addition to the 5-minute data. The central computer system shall determine the start of each cycle and send a begin-to-transmit command to the detector pre-processor to obtain the necessary data.

3.3.1 CALCULATION OF 5-MINUTE AND CYCLE VOLUME AND OCCUPANCY

The 5-minute and cycle by cycle volume and occupancy data for each or specified detector shall be calculated by subtracting the previous accumulated counts from the current accumulated counts.

3.3.2 DETECTOR TESTS

The central computer shall check the 5-minute volume and occupancy data for reliability by comparing them to a set of upper and lower threshold values. In the case of volume data, a detector shall be judged as normal, marginal, or unacceptable according to the following:

1. Let VL(1) and VU(1) be the first set of lower and upper volume thresholds.

2. Let VL(2) and VU(2) be the second set of lower and upper volume thresholds with VL(2) smaller than VL(1) and VU(2) larger than VU(1).

3. If the 5-minute volume falls between VL(1) and VU(1), the detector is judged to be normal. If it falls outside of VL(1) and VU(1) but inside of VL(2) and VU(2), the detector is judged to be marginal. If it falls outside of VL(2) and VU(2), the detector is unacceptable.

The same procedure shall be used to test the occupancy data. The worse of the volume or occupancy tests defines the detector status and shall be memorized as the current status of the detector. The Tenderer may propose a different method of detector checking if it is equally reliable.

3.3.3 TRAFFIC INDEX, CONGESTION INDEX AND QUEUE STATUS

Various traffic index, congestion index and/or queue status may need to be determined by the central computer for traffic responsive control and monitoring purposes using the volume and occupancy data. Although some procedures are described in these specifications, they may be altered by the ENGINEER before the system design is finalized and the Tenderer may propose alternative methods of equal effectiveness. The final methodologies shall be proposed by the CONTRACTOR and approved by the ENGINEER in the system design stage of the Project.

All weighing, adjusting, and smoothing factors and all threshold values shall be user specified and can be changed through the work stations.

3.3.4 TRAFFIC FLOW DATA

Seven (7) consecutive days (full days) of the 5-minute volume and occupancy data and detector status shall be continuously stored and updated (moving update) in the data hard disk memory of the central computer system so that they can be displayed or printed out at any time upon request of the operator. Permanent records of the data, condensed into 60-minute counts, shall be stored in the magnetic tape.

3.3.5 TRAFFIC COUNTS

At designated locations, one or several detectors shall form a traffic count station. The 5-minute volumes (raw counts) shall be adjusted by pre-stored adjustment factors to account for under or over counting and the counts of all detectors shall be combined to determine 15-minute and hourly sectional total. The system shall meet the following requirements:

1. It shall be possible to assign different adjustment factors for different detectors.

2. Both raw counts and adjusted counts shall be summarized into 15-minute, hourly, and daily total and stored in the daily report.

3. Unacceptable data shall be discarded and its value estimated from adjacent detectors or from previous time period(s) but estimated data shall be indicated in the report. The method of estimating the missing data shall be proposed by the CONTRACTOR in the system design.

4. It shall be possible to assign any detector as a traffic count detector.

4.0 EQUIPMENT MONITORING

4.1 CONTROL CENTER EQUIPMENT

The ATC system shall monitor operating status of control center equipment constantly, detect malfunction or abnormality, and alarm the operator of equipment failures. The monitoring system shall make use of a status display panel and audible alarm located on the operator console and the console typewriter for the computer system.

4.1.1 STATUS DISPLAY PANEL AND AUDIBLE ALARM

A central equipment status display panel shall be provided on the operator console for equipment status and malfunction monitoring purpose. This panel shall be approximately 30cm x 30cm in size and shall contain a system block diagram showing all control center equipment and their linkages. Operating status of each equipment shall be displayed by back-lit the corresponding block. White and red back-lit lights shall mean normal and failure conditions respectfully. Blocks of standby equipment shall be without background lights.

An audible alarm and an acknowledgement button shall be provided on the panel. The alarm shall be activated immediately upon detection of an equipment failure; at the same time, the equipment block shall display flashing red. The audible alarm shall be silenced by pressing the acknowledgement button; the flashing red display shall then be changed to steady red and shall remain unchanged until the equipment is returned to normal operation.

4.1.2 CONSOLE TYPEWRITER

As a minimum requirement, error messages and identification information of the following types shall be printed out on the computer system's console typewriter for each occurrence of CPU, FEP, and peripheral equipment failure to assist in problem diagnostic and corrective action:

(a) Equipment name and identification number
(b) Type of failure
(c) Date and time of failure

4.2 FIELD EQUIPMENT

4.2.1 LOCAL CONTROLLER

Operating status of local controllers shall be displayed on the wall maps as specified in the Wall Map section of these specifications. Error

events which can be identified by the local controller (power failure, green conflict, failure to advance, interval too short, transmission line error, etc) shall be stored in the local controller and transmitted to the central computer daily and, immediately, when requested by the operator.

4.2.2 DETECTOR

The status of each detector shall be determined by the testing of the 5-minute volume and occupancy data as specified in Section 3. Failure to transmit data shall also be detected and identified as a failure status. Marginal and unacceptable conditions and transmission failure shall be displayed on the maintenance wall map.

4.3 STATUS AND FAILURE EVENT RECORDS

Each and every failure event of the central and field equipment and the detector data status for each 5-minute period for at least the most recent 7-day period shall be stored in the CPU permanent hard disk device to allow immediate retrieval by the operator through the work stations. These data shall be condensed daily according to the requirements of the daily report and permanently recorded in magnetic tapes.

5.0 MAN-MACHINE INTERFACE

5.1 GENERAL

Man-machine interface functions shall be provided through operator console, work stations, wall maps, and computer system console typewriters. In addition to the requirements of this section, monitoring of equipment operations for error events or failure conditions shall also conform to the provisions of Section 3, "EQUIPMENT MONITORING."

Equipment operation functions which are considered regular routines such as loading and transfer of programs, saving backup copies of database, etc. may not be specifically described in this section but shall be understood to be required.

5.2 OPERATOR CONSOLE

Appropriate switches, push-buttons, and indicator lights shall be provided on the operator console for the control of wall map display and CCTV system, and acknowledgement of equipment failure alarms and manual control request. A central equipment status display panel as specified in Section 4 of these specifications shall also be installed on the operator console.

5.2.1 CONTROL OF WALL MAP DISPLAY

Control of the wall map displays in the control room shall conform to the following:

(a) It shall be possible to request display of any one or a combination of the status lights on the wall map.

(b) It shall be possible to extinguish all display lights on the wall map.

5.2.2 CONTROL OF CCTV SYSTEM

Control of the CCTV system is described in Division 3 of the Technical Specifications.

5.2.3 LOCAL MANUAL CONTROL

A section of the operator console shall be used to place an assembly consisting of a matrix of push-buttons, each corresponding to an intersection, for the purpose of monitoring manual control request and enabling local manual control.

A total of 400 rectangular shaped buttons arranged in a 20x20 matrix format shall be provided. Each of the buttons shall be approximately 20mm x 15 mm in size and be separated by a space of about 5 mm. The buttons shall be constructed of acrylic material with a flat transparent surface and a space to insert an identification tag beneath the surface without needing to remove the button from the assembly.

(a) Normal Operating Procedure

When the request for manual control is received from an intersection, the corresponding button shall display a flashing green light. By pressing the button when the flashing green light is showing, manual control is enabled; the display is then automatically changed to steady green. The green light shall be extinguished when the intersection is returned to central computer control.

(b) Manual Control Inhibition

Means shall be provided to prevent abusive use of the manual control enablement buttons as described above. This can be done by establishing a "Manual Control Enable" table in the control database. This table shall indicate when (Time-of-day) certain intersections are not allowed to be operated under the manual control mode. The format may be as illustrated below.

Time-of-day	Intersection Number
7:00-8:00	xxx, xxx, xxx-xxx
16:30-18:30	xxx-xxx, xxx, xxx, xxx, xxx

In the above illustration, "xxx" indicates intersection number and xxx-xxx indicates intersections between the two numbers.

Based on this table, an inhibit code is applied to the corresponding buttons which shall be indicated by a steady red light. When a manual control request is received while the inhibit code is present, the button shall be inactive. To permit manual operation, the operator shall have to use the work station to remove the "Inhibit" code and then press the enablement button; this, however, shall not change the "Manual Control Enable" table.

5.3 WORK STATION

The work station shall be a microcomputer based system complete with disk storage devices, CRT terminal, keyboard, and mouse. Three identical work stations shall be provided which shall function in parallel, each with the complete capabilities as specified herein.

The work stations shall be used for real-time signal control, database management, equipment monitoring, and traffic flow monitoring. They shall also be used for processing historical traffic and control data, editing and printing of daily and monthly reports, and off-line traffic engineering functions such as timing plan development, maintenance management, and traffic analysis.

The CONTRACTOR shall develop a series of CRT screen displays containing pertinent information for the various functions. Retrieval, display, editing, and printing of the information shall be guided by a menu driven process with adequate on-screen status and command lines necessary for a user-friendly type operation. All editing functions shall be provided with adequate error and reasonableness checking and confirmation procedures to ensure a fail-safe operation.

5.3.1 SIGNAL CONTROL FUNCTIONS

Signal control functions to be performed through the work stations shall include, among others, the following:

(a) Change of control mode
(b) Enabling and disabling manual control
(c) Manual timing plan, including phase sequence, selection
(d) Real-time monitoring of control mode, timing plan/timing parameter selection or formation, and traffic data

5.3.2 DATABASE MANAGEMENT

Database management functions to be performed through the work stations shall include, as a minimum, the following:

(a) Adding and editing timing parameters
(b) Adding and editing time-of-day plans
(c) Changing control area configuration
(d) Changing detector assignments (function and area)
(e) Changing threshold values, weighing factors, and adjustment factors
(f) Adding and editing various equipment identification codes, e.g. intersection number

(g) Download and upload of control and monitoring data to and from local controller.

5.3.3 EQUIPMENT MONITORING

It shall be possible for the operator to request, through the work station, display (on the CRT) or print-out of selected equipment status and failure records which have been stored on the CPU permanent storage hard disk. It shall be possible to make the selection by specifying the following:

(a) Single intersection
(b) All intersections in a control sub-area
(c) All key intersections
(d) Single detector
(e) All detectors in a control sub-area
(f) All detectors
(g) All control center equipment
(h) Single day (in conjunction with (a) to (g))
(i) Last 7 days (in conjunction with (a) to (g))

5.3.4 TRAFFIC AND CONTROL DATA PROCESSING

Traffic and control data processing functions to be performed through the Work Stations, using the 7-day data stored in the CPU hard disk, shall include, as a minimum, the following:

(a) Five-minute mode of control and volume data associated with a key intersection.
(b) Five-minute volume, occupancy, traffic index, congestion index, timing parameters, etc. associated with a key intersection or a control subarea.
(c) Fifteen-minute and hourly volume and occupancy and status of one, or a group, or all detectors.

5.3.5 DAILY AND MONTHLY REPORTS

It shall be possible for the operator, through the work stations, to control printout of daily and monthly reports. The control capabilities shall conform to the following:

(a) It shall be possible to set two modes of print-out: automatic by time of day, or manual request only.

(b) It shall be possible to suppress print-out of any one, or two, or three of the four sections (i.e. controller, detector, control center, and manual intervention) of the reports.

(c) It shall be possible to specify which detectors are to be included in the volume data portion of the reports.

5.4 WALL MAPS

Two wall maps shall be installed for traffic condition and equipment monitoring purposes. Both maps shall cover the entire project area as well as areas which would likely be included when the system is expanded in the future. The area of coverage is indicated on the Plans.

Each of the wall maps shall include a "date" display and a digital display of system clock, accurate to within one second, at the upper right hand corner.

5.4.1 TRAFFIC CONDITION WALL MAP

This wall map shall be approximately 6m x 6m in size and shall be installed in the control room. The display shall include a schematic background street network and status indicator lamps. The following real-time information shall be displayed upon request of the operator through the use of push-buttons on the operator console:

(a) Intersection Status - Use one multi-color lamp to display the following:

1. On-line intersections - steady green
2. Standby status intersections - Flashing green
3. Manual Control intersections - steady red
4. Off-line intersections - steady yellow
5. Intersections on Flashing - Flashing yellow

(b) Intersections in Phase one green steps - steady green

(c) Queue Status - Use one multi-color lamp for each detector to display the following:

1. No information - blank
2. Queue less than 300 meters - steady yellow
3. Queue between 300 and 600 meters - steady red
4. Queue longer than 600 meters - flashing red

A lamp test button shall be installed on the operator console for testing burned out lamps.

5.4.2 EQUIPMENT MONITORING WALL MAP

This wall map shall be approximately 3m x 2m in size and shall be installed in the computer (or equipment) room. The map shall be divided into three sections, a 2m x 2m section to the left and two 1m x 1m sections to the right.

The larger 2m x 2m section shall contain a schematic background street network, which shall be identical to that shown on the control room wall map but drawn to a smaller scale, and status display lights. The following shall be displayed automatically on a real-time basis:

(a) Intersection status : Green - normal
Yellow - no communication
Red - Controller failure

(b) Detector status : Normal - steady green light
Marginal - steady yellow light
Unacceptable - flashing yellow light
Transmission Failure - steady red light

Marginal and unacceptable detector status shall be displayed only if the condition lasts at least 15 minutes and such displays shall not be changed to normal indication until the detector has been judged to be normal for at least 15 minutes.

The lower 1m x 1m section shall display a map of the entire Bangkok metropolitan area showing all major streets and the outline of the project area. The street network shall be drawn to scale.

The upper 1m x1m section shall display the same information as specified for the central equipment display panel located on the operator console (see Section 4).

A lamp test button shall be installed on the wall map for testing burned-out lamps.

6.0 DATA RECORDING AND REPORTING

6.1 DATA RECORDING

Control mode, equipment status, traffic data, and manual intervention events shall be stored in the CPU permanent storage hard disk device and the magnetic tape unit for record keeping and analysis purposes.

6.1.1 CPU HARD DISK

As a minimum, the following data for the most recent 7 days shall be stored in the permanent storage hard disk device of the CPU:

(a) Status and control mode by 5-minute interval
(b) Selected timing parameters and/or timing plans by 5-minute interval or their times of change
(c) 5-minute volume, occupancy, and status of each detector
(d) Cycle by cycle volume and occupancy of detectors assigned for key intersection control
(e) 5-minute traffic index, congestion/saturation index, etc. used for timing plan selection.
(f) Cycle by cycle congestion/saturation index used for key intersection split and offset adjustments
(g) Central equipment failure events and time of occurrence
(h) Manual intervention events and time of action
(i) Complete local controller database

6.1.2 MAGNETIC TAPE

Data in the CPU hard disk shall be automatically condensed daily into daily report and transmitted to the magnetic tape unit for permanent storage. Data processing for the production and formatting of the daily report shall be done by the CPU as a background function at midnight of each day.

Types of data and for any time period stored in the CPU hard disk should also be possible to be transferred to the magnetic tape when requested by the operator through the work station.

Processing of the monthly report shall be done only upon receiving commands from the operator through the work station. It shall be possible to perform this task at any time.

6.2 DATA REPORTING

Data reporting shall include printout of 5-minute and/or cycle by cycle data stored in the CPU hard disk and daily and monthly reports data stored on magnetic tapes.

6.2.1 HARD DISK DATA

Subject to approval of the ENGINEER, the exact formats to be used for displaying (on CRT) and printing out the hard disk data shall be developed by the CONTRACTOR in the system design stage of the Project. Up to twenty (20) different reports may be required.

6.2.2 MAGNETIC TAPE DATA

The daily and monthly reports shall be divided into at least four sections: intersection, detector, control center, and manual intervention.

The daily report shall consist of 60-minute controller and detector status, volume counts and average occupancy condensed from the 5-minute data, central equipment status, and manual intervention log. The 60-minute volume and average occupancy data shall include daily total by each detector and by the group of detectors which constitute a traffic count station.

The monthly report shall consists of average hourly volume by day of week and for the whole month, and a failure event summary showing frequencies of each identifiable type of failure.

Subject to approval of the ENGINEER, the exact report formats shall be developed by the CONTRACTOR in the system design stage of the Project.

7.0 SOFTWARE

7.1 GENERAL

The following software packages and functions shall be provided for use with the ATC system:

(a) A real-time multi-programming operating system (executive system)
(b) Dual computer system operation functions
(c) Language compilers
(d) Utility programs including program development aids
(e) Diagnostic programs
(f) Housekeeping routines
(g) Traffic control software
(h) Traffic Data gathering and Processing software
(i) Equipment monitoring and fail-safe operation software
(j) Man-Machine interface control software
(k) Data recording and reporting software

7.2 MULTI-PROGRAMMING OPERATING SYSTEM

A real-time multi-programming operating system conforming to or exceeding the following shall be provided:

7.2.1 SOFTWARE TO BE CONTROLLED

All computer programs, computer software and traffic software shall operate under the control of the operating system. The operating system shall be disk based with foreground/background capability.

7.2.2 TRAFFIC CONTROL PROGRAM

The operating system shall be capable of supervising the operation of the real-time traffic control program, and servicing all requirements of said program, including on-line debugging, on-line diagnostics and on-line system testing.

7.2.3 INTERRUPTIONS AND OVERRIDES

The operating system shall save selected registers, and, if necessary, any intermediate data used by the program shall be placed in temporary storage for interrupted or overridden programs.

7.2.4 INPUT/OUTPUT

The operating system shall be capable of servicing any input-output request from any program.

7.2.5 EQUIPMENT MONITORING PROGRAM

The operating system shall be capable of supervising the operation of system equipment monitoring programs and servicing all requirement of said programs, which are required to detect system equipment failures (wherever possible) and inform the operator by means of a message containing as much diagnostic information as is possible or practical. If an equipment fails, it shall be possible to assign an existing alternative device with compatible data rates and similar functions automatically and/or manually.

7.2.6 OTHER FUNCTIONS

The operating system shall provide for operator control of program loading, program initiation, suspension and termination, peripheral equipment, and other standard computer functions necessary for dynamic signal control operations.

7.2.7 REFERENCES

(a) The Tenderer shall provide in his Technical Proposal references that the real time operating system proposed has been in use on a work site in an application requiring similar functions for a minimum period of 3 years prior to the scheduled delivery time of the computer equipment. The intent of this requirement is to assure that the operating system has been debugged and will continue to be supported.

(b) The Tenderer shall include full details of any modification required to the operating system to meet the above requirements and any others that may be considered necessary for the implementation of this system.

(c) The CONTRACTOR shall keep the ENGINEER updated with information on changes to the Operating System.

7.3 DUAL PROCESSOR OPERATING SOFTWARE

The dual processor computer system operating software shall reset the computer watch-dog timer at regular intervals in both CPUs provided the following conditions are met:

(a) The processor passes the instruction test correctly
(b) The processor has completed all the repetitive tasks that must be completed in less than one scan period.

The dual processor operating software shall make sure that the working traffic control databases of the two processors are identical and any changes in one shall be reflected in the other.

7.4 HIGH LEVEL LANGUAGE COMPILERS

7.4.1 GENERAL

Two high level language compilers shall be provided as a minimum. They shall be suitable for running on the equipment provided.

7.4.2 COMPILERS REQUIRED

A C language compiler and a Fortran IV compiler shall be provided for the central computer system and the work stations.

If a Tenderer wishes to supply a different compiler, he shall include full details and reasons for his choice in his Technical Proposal.

7.4.3 MINIMUM REQUIREMENTS

The programs shall provide the following functions:

(a) allow the use of the full instruction set
(b) allow calls to and from routines written in either language
(c) allow the use of Operating system standard I/O drivers
(d) accept input from the System Hard disk and perform edit/update functions from the control terminal
(e) produce a detailed printout which shall include details of any errors in the input
(f) permit the insertion of debugging functions

7.5 UTILITY PROGRAMS

7.5.1 GENERAL

Utility programs shall consist of a complete set of utility routines to facilitate loading and linking of compiler output, dumping memory, dumping tape and disk files, listings, editing, duplicating files and converting between various input media.

7.5.2 MIXED LOADING

The program loader shall be capable of loading a program containing a mixture of FORTRAN language elements and C language elements, as well as overlays in either language.

7.5.3 LOADER LISTINGS

The loader shall also provide listings of pertinent information relating to the relocation of each program element such that a programmer can easily relate each location in a memory dump back to the original language source code.

7.6 DIAGNOSTIC PROGRAMS

7.6.1 GENERAL

Maintenance and diagnostic routines shall be supplied to support the digital computer system. These routines shall provide the capability of identifying the existence of computer malfunctions.

7.6.2 MINIMUM REQUIREMENTS

(a) Diagnostic programs shall, as a minimum, consist of a set of diagnostic routines to check the following:

1. *computer memory*
2. internal instructions
3. input-output interface
4. input-output channels
5. interrupt system
6. peripheral equipment
7. control desk equipment.

(b) Diagnostic programs shall always produce a response when they are running successfully. The error messages generated shall indicate the type of failure and actions which may be required to rectify the failure.

7.7 HOUSEKEEPING ROUTINES

7.7.1 SCHEDULING FUNCTIONS

(a) A scheduling routine shall be provided to schedule the execution of each real-time function or sequence of such functions.

(b) The timing function schedules the execution of repetitively performed routines based on the receipt of real-time clock interrupts and counting down of specified timing intervals. However, there shall be provision for scheduling of routines in

accordance with information received from the man-machine interface and internal programs generated scheduling requests.

(c) Execution of scheduled routines shall be initiated in accordance with specified priority. Priority levels shall be established such that in the event of a timing conflict between two or more routines, the one with the highest priority will be executed first, interrupting, if necessary, a currently operating routine of lower priority.

(d) The scheduling routine shall cause at least the following set of functions to be executed with timing and priorities consistent with program functional requirements.

1. Input of controller monitor data at intervals not greater than one second.
2. Processing of detector data input at intervals not greater than one second.
3. Output of controller hold-on-line, timing, special function and monitor data request commands at intervals not greater then one second.

(e) The processing of CPU traps or interrupts indicating serious system malfunction or power failure shall preempt the normal traffic signal control program operations.

7.7.2 INPUT/OUTPUT FUNCTIONS

(a) The traffic signal control program shall be capable of controlling all input and output functions necessary for the proper operation of the program either directly or by means of the real-time operation system.

(b) Verification shall be available to the traffic signal control program that all transmissions of data were complete and that all automatic validity checking procedures, such as party checking, were accomplished satisfactorily.

(c) Status of any transmission failure shall be available for the purpose of recovery and reporting. The input functions shall provide separate inputs to the traffic signal control program from each detector, traffic signal controller and each input control from the man-machine interface.

(d) The output functions shall provide separate outputs from the traffic signal control program independently to each controller or display point of the man-machine interface.

(e) Output of data to the man-machine interface shall be generated by the traffic signal control program in a manner consistent with the capabilities of the interface equipment and specified console/display operating requirements.

(f) All CRT and Report headings shall be in English.

7.8 START-UP PROCEDURE

7.8.1 GENERAL

The start-up procedure includes operator action to load the programming system and initiate traffic signal control program execution and program action to set up initial conditions prior to transferring traffic signal controllers from local control to computer control.

7.8.2 SEQUENCE

Operator start-up procedures shall be simple, straight forward and automatic. Once the computer power has been turned on and peripheral equipment set up, it shall merely be necessary to press a bootstrap load button or key in a simple command in order to load and start the real-time operating system, read in time of day and date from the external clock, load and start the traffic signal control program, be ready to transfer traffic signal controllers from standby to computer control, and begin performing all other real-time operating system and traffic signal control program functions. Nevertheless, the operator shall optionally be able to exercise supervisory control over these functions, including, but not limited to, selection of the data logging medium.

7.8.3 MINIMUM REQUIREMENTS

After load, the traffic signal program shall begin by performing at least the following functions:

(a) Test the operator control panel to see if standard procedures are to be adopted and, if not, wait for operator to key in special instructions for subsequent processing.

(b) Read basic intersection tables, monitor tables, etc., from traffic data base.

(c) Read in restart data, if any, from disk including intersection and detector failure and repair status parameters and any other necessary status parameters. The restart data shall have been stored at the conclusion of the previous traffic signal control program run.

(d) Set up all required initial conditions.

(e) Initiate real-time clock interrupts and wait for clock interrupt to transfer control to the scheduling routine.

Once control has passed to the scheduling routine, all other functions of the traffic signal control program shall become available for execution.

7.9 SHUTDOWN PROCEDURE

7.9.1 GENERAL

The shutdown procedure includes operator or program action to initiate traffic signal control program termination and program action to record failure and other status arrays or data necessary for restart, and to stop the program.

7.9.2 PLANNING OR EMERGENCY SHUTDOWN

Shutdown of the traffic signal control program shall provide for planned shutdown by operator request and emergency shutdown by machine request in the event of self-detected malfunction. Standby requirements (see paragraph 7.10.7) do not apply unless standby was invoked prior to initiations of shutdown.

7.10 TRAFFIC CONTROL SYSTEM SOFTWARE

7.10.1 GENERAL

These computer programs include a traffic signal control program, auxiliary support programs such as database management programs, traffic data retrieval and processing routines, equipment monitoring routines, man-machine interface routines, and data recording and retrieval routines necessary to provide the functions described in these

specifications. The traffic control system programs shall communicate with the traffic signal controllers, detectors and peripheral equipment.

7.10.2 SOFTWARE DEVELOPMENT

It is recognized that the time schedule established for this project and the desire for a proven software package may precludes extensive software development effort. The Tenderer should note that existing software packages with appropriate modifications will be considered if they meet the intent of these specifications. Nevertheless, the software to be provided shall meet the following criteria:

(a) All application programs are initially written in high level language(s).

(b) It is easy and simple to prepare initial inputs to the database and to make subsequent modifications to the database. The users of the system should not be expected to be experienced programmers.

(c) The software is modular so that advances in the state-of-the-art in traffic control can be implemented at reasonable costs.

(d) The software provides for safe, efficient and flexible traffic control. The critical functions are:

1. The method used to transfer a controller from local control to computer control and vice versa must not cause dangerously short display intervals.

2. Capacity for at least 20 timing plans and 4 daily timing plan schedules for each local controller.

3. The method for changing parameter values, at least for timing plans, must be simple and require only a short time.

4. The method used to select timing plans must be reliable and flexible to accommodate changes in traffic conditions.

(e) The traffic software, as delivered shall be capable of controlling 400 signalized intersections with 1600 detectors.

(f) Orderly system shutdown procedures are required for scheduled interruptions; in the event of accidental or unscheduled

interruption of control there shall be provision for corrective service to expeditiously restore control.

(g) Entry of data into the database shall be simple and straight forward. For example, if a change in offset is entered, no other timing changes shall be required. If a data item is used in more than one part of the program it shall not be required to duplicate the input of that item.

7.10.3 DIFFERENCES TO BE DESCRIBED

The Tenderer shall describe in his Technical Proposal how his proposed software differ from the requirements of these specifications. The descriptions shall be in sufficient detail to permit the BMA to evaluate the significance of the differences.

7.10.4 BACKGROUND ANALYSIS ROUTINES

Furnishing of background traffic analysis routines are not a part of this specification but there shall be provision for user furnished traffic analysis or other application programs to operate as background programs concurrently with real-time traffic signal control programs.

The Tenderer shall describe briefly in his Technical Proposal any background programs which are available and identify whether these are part of his standard software package or as extra cost options.

7.10.5 TRAFFIC CONTROL PARAMETERS AND TIMING PLANS

Traffic control parameters, timing plans, and timing parameter selection threshold values necessary to effect optimum operations of the signals shall be developed and implemented by the CONTRACTOR. The procedures and methods to be used by the CONTRACTOR to develop the timing plans and the threshold values shall be described in detail in the System Design report.

No new signal shall be turned on until the timing plans have been installed.

(a) Data To Be Provided by BMA

The CONTRACTOR shall receive from the BMA office the following traffic and system related data :

1. Intersection traffic volume counts - hourly volume during a 13-hour period on a week day

2. Distance between intersections

(b) Timing Plans for On-line Control

The CONTRACTOR shall prepare timing parameters and threshold values to be used for traffic responsive control, and time-of-day timing plans for the front-end processors and local controllers. The prepared timing parameters and plans should be designed to operate in different traffic conditions during morning peak, day time off-peak, lunch time peak, afternoon peak and night time. The number of time-of-day timing plans required will vary depending on variations in traffic conditions but a minimum of three (3) plans shall be prepared for each signal.

(c) Timing Plans for Off-line Control

Timing parameters for isolated control and fail-safe fixed-time control shall be developed for average weekday conditions.

(d) Fine Tuning

The CONTRACTOR shall, with the assistance of BMA staff, fine tune the initial timing parameters, timing plans, and threshold values by conducting a series of field observations and adjustments.

8.0 CENTRAL COMPUTERS

8.1 GENERAL

This section describes the minimum equipment requirements of the central computer system, i.e. central processor and front-end processor units.

The Tenderer shall fully describe the computer system offered in his Technical Proposal.

8.2 CENTRAL PROCESSOR UNITS (CPU)

8.2.1 MINIMUM HARDWARE REQUIREMENTS

Two sets of identical central processor units shall be provided in the Computer Room.

(a) The central processor units shall use 32-bit processors and shall meet the following minimum specifications:

1. Multiple access path structure.
2. 8 general purpose registers excluding any used for indexing.
3. Capable of operating on single bit, 8-bit, 16-bit, 32-bit words.
4. At least 10 megabytes each of internal direct addressable memory.
5. Hardware floating point operation.
6. Alterable memory protection.
7. 64 KB or larger Cache memory.
8. Hardware priority interrupt structure.

(b) The processor unit shall have a full range of instructions that can be implemented in a single process or instruction.

(c) The processor speed shall be in the range of 1,000,000 instructions per second or better, based on a mixture of instructions appropriate for real-time control of traffic signals.

(d) The processor unit shall have a full range of interrupts to cater for the following:

1. Power Failure
2. Clock/Timer
3. Console input

4. Illegal instruction or privileged instructions violation
5. Memory protection violation
6. Input/Output

(e) The processor unit shall be equipped with a watchdog timer which shall provide an output signal if it has not been reset by the processor within a preset time interval. The reset signal shall be generated by program and shall only output when the processor hardware and software are operating correctly. The watchdog reset interval shall not exceed 1 second.

(f) The processor unit shall be fitted with a operations console which shall have the following facilities:

1. Run, Halt, Reset the processor.
2. Automatic program load (bootstrap loader).

(g) The RAM memory shall have multiple access paths to allow input/output functions to be performed concurrently with arithmetic and logical functions.

(h) The RAM memory shall be protected by an error detection/correction code capable of correcting single bit errors.

(i) The RAM memory shall not be corrupted by mains power failure.

(j) The internal memory of the processor unit shall be capable of expansion to 40 megabytes or greater by simple addition of plug-in memory modules.

(k) The amount of internal memory to be supplied shall be that required to perform the system functions within the specified response time while providing at least 50% spare capacity when the ATC system is expanded to include 400 signals. The CONTRACTOR shall provide necessary load indicator program to demonstrate that this requirement is met.

(l) It shall be possible to use the standby CPU for off-line processing.

8.3 CPU CONSOLE AND TYPEWRITER

Each of the CPUs shall be equipped with a desk top control console and printer for operation, monitoring, and system maintenance purposes.

8.3.1 CPU CONSOLE

The CONTRACTOR shall install two sets of identical console each complete with a CRT unit and a key-board in the Computer Room.

The CPU console shall perform all standard computer operation and maintenance related functions such as system start up, program loading/unloading, execution, input/output control of peripherals and allow off-line use of the computer.

The CRT unit shall be a 14-inch color monitor. The keyboard shall be a full-size unit with numerical pad and arrow keys.

8.3.2 CONSOLE PRINTERS

The console printers shall be used to record the system operational and malfunctional log.

The printers shall meet the following minimum specifications:

(a) full 128 character ASCII standard set.
(b) matrix impact printer.
(c) low noise operation.
(d) line width - adjustable 80-132 characters.
(e) print speed - more than 150 characters per second.
(f) automatic line feed and carriage return.
(g) data transfer speed - 9,600 board/sec or more.
(h) The printer shall operate on fan-fold paper and shall be supplied complete with paper dispenser and collecting trays.

8.4 FRONT-END PROCESSORS (FEP)

8.4.1 GENERAL

Six (6) sets of front-end processors (FEPs), arranged in three (3) dual processor (one main and one backup) configuration, shall be installed in the control center. Automatic switching devices shall be installed as part of the FEP assembly.

Each front-end processor shall be a micro-processor based device performing primarily data pooling and distributing functions between the CPU and the field equipment. It shall have a minimum of 64 communication channels and sufficient capacity to control up to 64 local controllers, processing data from 256 detectors and meet all functional requirements of the ATC system.

8.4.2 SYSTEM CONTROL FUNCTIONS

Under the concept of distributed processing system, certain tasks of the ATC system are best performed by the front-end processors. A list of these tasks are identified in this section for references; the final division of tasks between the CPU and the FEP shall be developed by the CONTRACTOR in conjunction with the hardware and software design of the central computer system.

(a) Receive detector data from detector data pre-processors
(b) Perform detector data reliability check
(c) Send traffic responsive or time-of-day timing parameters to local controllers
(d) Send updated local time-of-day timing plans to local controllers
(e) Send "Transmit Data" command to detector data pre-processors (see Section 3)
(f) Receive local controller error codes (carrier drop, green conflict, etc.)
(g) Monitor transmission errors
(h) Receive phase codes from local controllers
(i) Obtain system time from the system clock
(j) Transmit system time to local controllers
(k) File maintenance processing
(l) Communications processing to/from the CPU
(m) Communications processing for wall map displays
(n) Communications processing to/from the communication control units which distribute the signals for each channel

8.4.3 EQUIPMENT SPECIFICATIONS

The FEPs shall meet the following minimum specifications:

(a) 16-bit or more processor
(b) 1 megabytes of battery backed internal memory
(c) 400,000 instructions per second

9.0 PERIPHERALS

9.1 GENERAL

The central computer system shall be provided with peripheral equipment as described in this section.

9.2 SYSTEM EXTERNAL CLOCK

The system external clock shall meet the following minimum requirements:

(a) The clock shall provide the CPU and FEP with the day, date and time (hours, minutes and seconds).

(b) The clock shall be crystal controlled and keep time to an accuracy of better than 1 second per day.

(c) The clock shall have an integral battery or equivalent which shall be capable of powering the clock for 7 days. The lifetime of the battery or equivalent shall be not less than 5 years.

9.3 SWITCHING UNIT

The switching unit shall be capable of switching the standby CPU and the peripheral equipment into operation, after having received the switching signal which is automatically generated by either CPU. A manual switching mechanism shall also be provided.

Connection or disconnection of the equipment to the on-line system while it is operating shall not affect its operation in any way.

The peripheral equipment to be connected to the standby CPU by the switching unit shall be automatically designated from the switch unit and shall include the following:

(a) Traffic condition monitoring Wall map
(b) Equipment monitoring Wall map
(c) System indication Panel
(d) Work Stations
(e) Line Printer (automatically and manually)
(f) Magnetic Tape units (automatically and manually)

The switching status of the peripheral equipment shall be displayed on the switching unit.

9.4 SYSTEM HARD DISK UNITS

The hard disk units for storing the programs including the source programs and objective programs shall meet the following minimum requirements:

(a) Two sets of identical hard disk units shall be provided in the computer room. Each hard disk unit shall be connected to a CPU.

(b) It shall be possible to exchange the disks without stopping the System operation.

(c) The disk shall be divided into sectors. The data held on a sector shall be protected by using a CRC code.

(d) It shall be possible to hardware write protect the data on the disk.

(e) The disk unit shall be capable of outputing malfunction signals to the CPU, and correct minor errors.

(f) The disk heads shall automatically retract in the event of a power failure. The disk shall start up automatically when mains power is applied. This shall not result in any need for head re-alignment.

(g) The average access time shall not exceed 30 m seconds.

(h) The disk controller shall be capable of transferring data at a rate of at least 1 megabytes per second.

(i) Each disk unit shall have a minimum capacity of 300 megabytes. The actual disk capacity shall be that required to implement the System facilities and provide 50% spare capacity when the system is expanded to 400 signals.

9.5 DATA HARD DISK UNIT

The data hard disk unit for storing common work data such as the fixed, variable and accumulated data in their files shall meet the following minimum requirements:

(a) One set of hard disk unit shall be provided in the computer room. The hard disk set shall be connected to both CPU's.