

**Traffic Systems
and Signing**

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Installation Guide for Urban Traffic Control

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MCH0010D

**INSTALLATION GUIDE FOR URBAN
TRAFFIC CONTROL**

Contents

Chapter

- 1 Introduction
- 2 UTC Operation
- 3 Design Considerations
- 4 Data Transmission
- 5 Implementation
- 6 Commissioning
- 7 Maintenance
- 8 Glossary
- 9 References
- 10 History

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1 INTRODUCTION

This document

1.1 This document is intended to provide local authorities with a comprehensive and informative guide to Urban Traffic Control (UTC) Systems. It is intended that this document will assist local authorities in the preparation of documentation for the invitation of tenders and subsequent installation of Urban Traffic Control Systems. As such, these Guidelines supersede the current document MCH 0010C, from the date of issue.

1.2 Information from MCE0312, MCE0360 and MCE0361 has been incorporated into this document. Those documents will be retained, because the information that is contained in MCE0312, MCE0360 and MCE0361 documents remains valid for older UTC Systems.

1.3 Any comments or enquiries relating to this document should be addressed to:

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Please note: Due to recent changes in the regulations for Statutory Type Approval local authority procurers are no longer required to obtain Statutory Type Approval for UTC Systems.

What is an UTC system?

1.4 Urban Traffic Control (UTC) systems are used to link together individual traffic signal installations. They control the starts and duration of the green periods given to traffic at adjacent sets of traffic signals along a route or within a road network. UTC systems are composed of some or all of the following components:

- i) on-street detectors (usually but not necessarily induction loops);
- ii) a strategy application which uses detector and other available information to determine signal settings;

- iii) traffic signals;

- iv) telecommunications services connecting detectors, the strategy application and traffic signals.

1.5 Local co-ordination may be achieved either by linking controllers by dedicated cable or by synchronising the controller clocks using either regular pulses from the electricity mains supply or a signal from an external time reference (such as the Rugby clock). If these systems are connected to a fault monitoring system, their operation can be modified or monitored centrally over the public switched telephone network. This arrangement is sometimes known as dial-up UTC and can be used where small groups of signals would benefit from co-ordination but the expense of a central computer is not justified.

1.6 Larger groups of signals are usually co-ordinated by a central computer, which sends electronic instructions by telephone type cables to each traffic signal controller. Local linking is often also used to provide a back-up facility in the event of a computer failure.

1.7 The optimal strategy to use depends on the characteristics of the route or road network and the traffic on it. Most centrally controlled UTC systems use a combination of fixed time control, which operates with a set of pre-designed signal plans, each of which can be implemented at any time, and traffic responsive systems which monitor traffic conditions in a network by some form of detection and react to the information received by implementing appropriate signal settings. The most widely used adaptive system in the United Kingdom is the Split Cycle and Offset Optimisation Technique (SCOOT). The Transport Research Laboratory (TRL Ltd) in collaboration with the UK System Suppliers developed this system, which can be used in combination with fixed time plan systems.

1.8 UTC systems may be used to implement or support a variety of traffic policies and strategies other than traffic management – for instance, air quality management, car parking management and bus priority. In this case, the UTC system may need interfaces to other detectors, applications or devices such as variable message signs. More sophisticated application of these policies can, however, be provided by integrating the UTC system within an Urban Traffic Management and Control (UTMC) system as described below.

UTC as an UTMC component

1.9 Historically, UTC systems (whether based on simple fixed-time plans or on sophisticated adaptive algorithms) have been implemented independently of other applications. However, this is changing as information technology becomes cheaper, more powerful and easier to use.

1.10 Today, UTC is better seen as merely a part of the wider use of technology that a local authority will deploy to meet its transport policy. Integration of UTC with other applications offers local authorities the opportunity to meet a variety of local and national policy objectives including:

- i) managing demand and congestion more effectively;
- ii) influencing modal choice, route choice and when journeys are made;
- iii) improving priority for buses and other public service vehicles;
- iv) providing better and safer facilities for pedestrians, cyclists and other vulnerable road users;
- v) minimising delays for pedestrians and bus passengers;
- vi) reducing vehicle emissions, noise and visual intrusion;
- vii) traffic restraint in sensitive areas; and
- viii) improving further overall safety.

1.11 Such a system – an ‘urban traffic management and control’ (UTMC) system – will consist of a wider range of components, integrated together. A typical UTMC system might contain:

- i) on-street detectors and controllers;
- ii) driver information facilities, including variable message signs;
- iii) CCTV cameras;
- iv) other urban systems including car park control systems;
- v) a common database;
- vi) a strategy management tool;
- vii) other UTMC systems;
- viii) public transport and other fleet management systems;
- ix) emergency service systems;
- x) inter-urban traffic management and control systems;
- xi) TV, radio and other media systems; and
- xii) systems of value-added service providers.

1.12 Figure 1.1 overleaf shows an example of how UTC (horizontal stripes) might be integrated into a more comprehensive UTMC system.

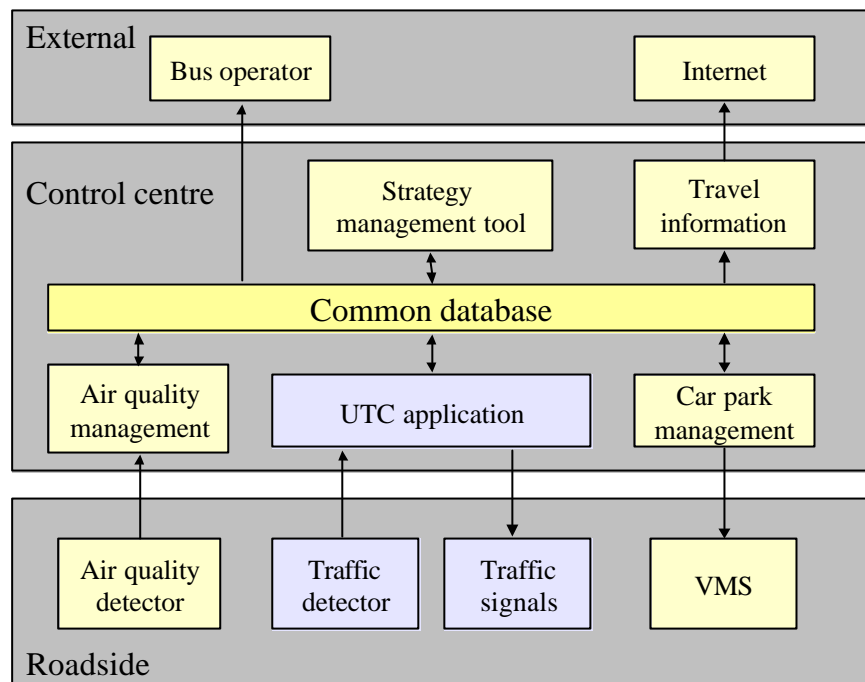


Figure 1.1 UTMC System

1.13 The Department of Transport, Local Government and the Regions (DTLR) sponsors a modular approach to the implementation of UTMC systems, based on open standards. DTLR offers a range of guidance and support to local authorities seeking to deploy such systems. More information may be obtained about this from:

Website: <http://www.utmc.org.uk>

Scope

1.14 These guidelines provide local authorities with an overview of UTC systems, which are controlled by central computers, to aid the preparation of documentation for the invitation of tenders for these systems and their subsequent installation.

Glossary

1.15 A glossary of terms can be found in Section 8.

2 UTC OPERATION

Operational Objectives

2.1 Co-ordinated signal systems, on their own or in combination with other network management technologies described in Section 1.3, provide an effective means by which traffic managers can implement a wide variety of flexible strategies for the management of a road network.

2.2 The systems can be used to obtain the best traffic performance from a network by reducing delays to vehicles and the number of times they have to stop. Where a network is not congested, this strategy also helps to reduce vehicle noise and pollution. Alternatively, in many urban areas, the systems can be used to balance capacity in a network, to attract or deter traffic from particular routes or areas, to give priority to specific categories of road-user or to arrange for queuing to take place in suitable parts of the network; for example, at places where the noise and fumes of waiting vehicles would cause less irritation to passers by or residents, or where convenient road space exists for queuing or where bus lanes have been provided.

Control Strategies

2.3 There are two basic types of control strategies, which can be employed in UTC systems either separately or in combination. These are:

- i) Fixed time control systems; and
- ii) Traffic responsive control systems.

2.4 There are many systems available for traffic control in urban areas, using co-ordinated signal systems. It is the responsibility of the design authority to choose a system that best suits their area, which is being considered for UTC

2.5 In Britain, the systems developed over the last 20 years are based on the use of TRANSYT and SCOOT as part of a UTC system, and are therefore the most commonly used. For this reason, TRANSYT and SCOOT have been chosen in this document, to illustrate some of the techniques used in UTC.

Fixed Time Systems

2.6 Fixed time systems operate with a set of pre-designed signal plans, each of which can be implemented either according to a timetable or by operator intervention from a central control point. A signal plan is a collection of co-ordinated settings for all the signals in a network. The signal settings in each plan are fixed in that the green periods and offsets do not vary from cycle to cycle. Thus fixed time systems control known patterns of traffic rather than respond to demand.

2.7 The preparation of signal plan involves representing the traffic condition in a network numerically and optimising the signal timings against various strategy and policy criteria. Although this can be calculated by manual methods in simple cases, computer techniques are usually used.

2.8 In Britain the most widely used technique for calculating signal settings is the TRANSYT computer programme developed by TRL. The programme models traffic behaviour and carries out optimisation procedures that calculate signal timings giving optimal traffic performance. The programme also provides extensive information about the performance of the network, including estimated delays, number of stops, journey times and fuel consumption.

2.9 It is important to check that the predicted cycle flow profiles give a reasonably accurate representation of actual traffic behaviour. If not, the model parameters within the programme must be modified until this is achieved. Even so, some additional fine tuning of the timings on site may be required.

2.10 Counting and occupancy detectors are often installed in fixed time systems to provide information about traffic conditions so that system operators can decide whether to intervene to run alternative traffic plans. Similar detectors can be used to select automatically the most suitable plan from a library of pre-calculated plans. Although this method provides a degree of self-adaptation to traffic conditions, it still requires the preparation of fixed time plans, rather than providing a gradual evolution of signal timings in response to changing traffic conditions. Traffic can be disrupted by frequent changes of plan and usually some restriction is placed on the frequency of such changes.

Traffic Responsive Systems

2.11 Plan generation systems generate their own fixed time plans from detector data and implement them. These systems eliminate the need to update fixed time plans but the frequent changes of plan can cause disruption to traffic at the time of the automatic plan change. Measures to overcome this problem have been developed recently as part of UTMC research project 01. The problem can also be avoided by the use of demand responsive UTC systems, which make frequent relatively small changes to traffic signal timings.

2.12 The system most widely installed in Britain is the Split, Cycle and Offset Optimisation Technique (SCOOT). SCOOT continuously monitors traffic flow over the whole network and uses this information in its on-line traffic model to decide whether small modification to the signal timings would be beneficial and if so, to implement them.

2.13 SCOOT adjusts signal timings by three optimisation procedures

- i) The Split Optimiser,
- ii) The Offset Optimiser,
- iii) The Cycle Time Optimiser.

2.14 Each optimiser estimates the effect of a small incremental change in signal timings on the overall performance of the region's traffic signal network.

2.15 The Split Optimiser works at every change of stage by analysing the current red and green timings to determine whether the stage change time should be advanced, retarded or remain the same.

2.16 The Offset Optimiser works once per cycle for each node. It operates by analysing the current situation at each node using the cyclic flow profiles predicted for each of the links with upstream or downstream nodes.

2.17 The Cycle Time Optimiser operates on a region basis, once every five minutes, or every two and a half minutes when cycle times are rising rapidly.

2.18 By the combination of relatively small changes to traffic signal timings, SCOOT can respond to short term local peaks in traffic demand, as well as following trends over time and maintaining constant co-ordination of the signal network.

SCOOT Enhancements

2.19 The SCOOT model is being continuously improved and its latest version includes modifications to make the splits and cycle time optimisers more flexible. It also includes the following facilities.

i) **Bus Priority.** A facility introduced to integrate active priority to buses or other public transport vehicles. The system was designed to allow buses to be detected either by selective vehicle detectors or by an Automatic Vehicle Location (AVL) system. SCOOT is able to give buses priority at traffic signals whilst causing little disruption to other traffic.

ii) **Estimate of Vehicle Emissions.** SCOOT Version 4.2 will provide estimates of the Carbon Monoxide, Carbon Dioxide, Oxides of Nitrogen, particulates and Volatile Organic Compounds (VOCs) emitted by vehicles on a link node or region basis.

iii) **Traffic Information Database.** A database known as ASTRID has been developed to take traffic information from SCOOT and to process and store it for later retrieval and analysis. Historic data from ASTRID can be used to replace the SCOOT model data from faulty detectors. It can also be used to provide an early warning and, therefore, to allow a quicker response to the onset of peak periods of traffic. Information from SCOOT detectors can also be used together with historic data from ASTRID to automatically detect incidents.

Linking UTC to other systems

2.20 UTC systems can be linked to other traffic management and control systems. The number of systems that can be interfaced to UTC systems, with or without a traffic responsive module is increasing. Local authorities are encouraged to discuss the interface requirements of their systems, as future developments may have produced a suitable facility.

2.21 Listed below are the systems that have interfaces to UTC.

i) **Parking Management and Diversions.** Variable Message Signs [VMS] systems are widely used to direct drivers to the nearest car park with available space or provide other driver information. Such systems can be linked to UTC systems.

ii) **Emergency Green Wave Routes.** This may be specified so that it could be implemented by remote request from fire stations. A rolling sequence of green signals is provided on successive junctions, along a predefined route, to provide the emergency vehicle with maximum priority. The usual method of calling the green wave is by a push button in the fire station. It is also possible to have a direct link from the fire service or other emergency control room to the UTC computer, which can provide a 24 hour response.

iii) **Fleet management systems for buses.** The bus priority facilities in the latest versions can use bus positions from the Automatic Vehicle Location (AVL) part of fleet management systems to provide priority to buses.

iv) **Fault Identification and Management.** UTC systems can be integrated with Fault Management Systems to enable faults to be automatically recognised and passed directly to the relevant maintenance contractor.

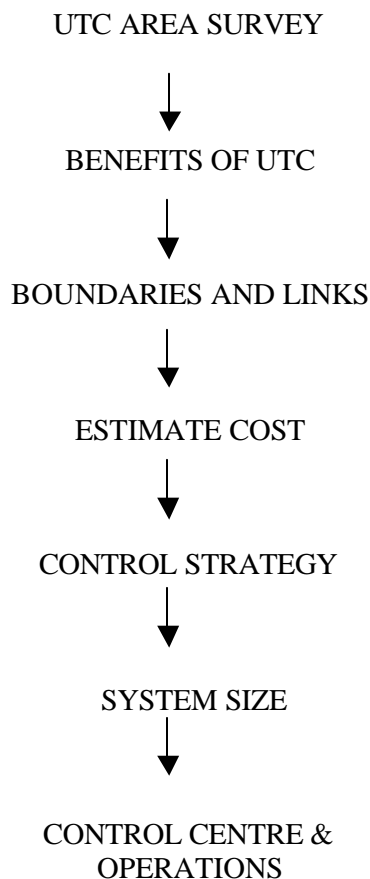
v) **Diversions.** UTC systems can accept instructions from an external source to implement a diversion automatically.

3 DESIGN CONSIDERATIONS

Overview

3.1 This section concentrates on the information required when considering the implementation of UTC in an area.

3.2 The main items to consider are as follows:



3.3 Further details are included within the following sections.

UTC Area Survey

3.4 When considering a new system, Authorities are advised to visit and discuss their ideas with suppliers and users of their systems.

3.5 A study of the area to be controlled by the UTC system should first be carried out and decisions made about system boundaries. The study must be made in a systematic way, considering each signalled area or route separately. Opportunity should be taken to make a critical appraisal of existing signalling arrangements, examining layouts and staging for possible improvements. UTC can often be justified for quite small areas (around a total of 10 traffic signals and signalled Pedestrian crossings) where traffic pattern exhibits cyclic downstream platooning at least during peak periods and additional benefits can also be gained from other facilities contained within the UTC package.

Benefits of UTC

3.6 As an aid to the designer when considering system boundaries, it is useful to bear in mind the benefits of UTC listed below, and determine their relevance to the area being studied.

- i) Reduction in journey times, number of stops, fuel savings and reduced environmental pollution due to signal co-ordination. Good community benefits are likely to arise from co-ordinating signals and Pedestrian crossings when the vehicle arrivals are platooned as a result of control at upstream junctions and when link travel times are less than 20-30 seconds normally or 60 seconds in particularly free-flowing conditions, depending on the nature of the links.
- ii) Improved serviceability of equipment due to continuous monitoring by the UTC system, and prompt fault reporting.
- iii) Reduced attendance time by emergency services using the green-wave technique.
- iv) Ability to impose a wide range of control strategies and diversions quickly and efficiently.
- v) Improved bus journey times can be achieved within fixed time systems by allocating a measure of priority to bus routes. Buses will benefit generally from the improved traffic flow arising from the implementation of UTC. Further improvements for buses within UTC can be achieved by adding link weighting to the model. Traffic responsive systems can also provide a facility for the provision of bus priority, which is activated by detectors or by a signal from a bus.

vi) Improved car park utilisation and reduction in the amount of circulating traffic with a Car Park Information System.

vii) Improved traffic management information can be made available from traffic responsive and fixed time systems.

viii) Possible reductions in the road improvements programme due to benefits from UTC.

3.7 Later versions of the TRANSYT program, used to determine the timings of fixed time traffic plans, can also estimate the community benefits in monetary terms to be gained from signal co-ordination. The additional benefits to be gained from SCOOT can be quantified in monetary terms by using the method described by D I Robertson and P B Hunt in "A method of estimating the benefits of co-ordinating signals by TRANSYT and SCOOT" (Traffic Engineering and Control, November 1984). This method takes account of the loss of efficiency of fixed time plans over a period of time, due to gradual changes in traffic flows. One benefit of a traffic responsive system is that the need to carry out traffic surveys to generate new fixed time plans (say every 3 years) is eliminated. However, traffic responsive systems do require skilled staff to design and validate the network models. In addition, subsequent changes to the network, to the use of land adjoining the highway and to parking and loading systems do affect traffic response system as much as fixed time systems. The information used to model the network has therefore to be reviewed periodically. This also provides an opportunity to review traffic management operations.

Boundaries and links

3.8 When the overall system boundary has been determined, it is often desirable, from an operational view, to divide the area into sub-areas. Each sub-area comprises a network, or a linear route, where the traffic signals would normally operate on the same cycle time. When determining sub-area boundaries, remember there may not be co-ordination between adjacent sub-areas. Therefore, wherever possible, cross-boundary links should be those where co-ordination is not important or where it would be difficult to achieve.

3.9 Examples of such links are: -

i) Long links, with a high degree of platoon dispersion.

ii) Lightly trafficked links, where co-ordination benefit is slight.

iii) Major sinks and sources on the link, disrupting co-ordination.

iv) Links with much roadside activity (parking, unloading etc) where co-ordination is reduced.

v) Links heavily congested for much of the day (standing queues destroy co-ordination but note that co-ordination can reduce queues if these are due to an incorrect offset).

vi) Heavy turning movements into the link, giving a flat traffic profile.

3.10 The above comments on fixed time sub areas also apply to the choice of Region boundaries in a traffic responsive system. The operation of the system may be more manageable if the two coincide. In this case, it is recommended that the Authority prepare diagrams of the traffic responsive system nodes in each region.

Getting estimates

3.11 An estimate of the total cost of the UTC system may be arrived at by obtaining budgetary estimates, from suppliers, for each of the separate contracts involved. These separate contracts would be typically:-

i) The main UTC contract; for supplying, installing and bringing into service:

Control centre equipment

Data transmission equipment

System facilities

ii) A contract for providing Data Transmission Circuits connecting OTUs to the control centre and a terminating frame at the control centre. The circuits and terminating frame are normally rented from a telecommunication company. An Authority may obtain circuits from another source but should ensure the line characteristics are compatible with the UTC system being purchased.

iii) A contract to modify where possible, or replace, existing traffic signal controllers to provide an interface to the UTC system and remote reconnect facility if required.

iv) A contract to supply and install new signals, and convert zebra crossings to signalled pedestrian crossings, where appropriate.

- v) A contract to carry out civil works, including trenching for any ducts required for other contracts (e.g. Provision of Data Transmission circuits and Loop Installation), and back filling.
- vi) A contract to slot cut for loops and feeders (though this work is often included in the main contract). Advice on loop siting and feeder lengths is given in MCH1352 'Technical guide to SCOOT loop siting'.
- vii) Provide control centre accommodation, including any special consoles required.
- viii) Provide a communications system between staff on the street and the control centre. Voice communications can be provided by radio systems or by mobile phones, which also can provide data communications. In addition it is recommended that a remote terminal, which communicates directly with the UTC computer and allows a control and reply capability to be exercised from the roadside is purchased from the system supplier. This can be of benefit not only during validation but also during normal operation and maintenance.
- ix) Provide and install variable message signs. This is usually by one of the specialist sign manufacturers.
- x) In large urban areas, where the size and complexity of the UTC system may require the presence of a trained operator in the control centre, the provision of a closed circuit television (CCTV) systems is recommended. This would provide additional information to the operator at critical intersections in the network. It may be that this facility could be shared with the police, town centre manager and/or Passenger Transport Authority.

Control strategy

3.12 The following sections provide details of design considerations, and information, which must be included in the Works Specification for the main UTC contract. That is, facilities required such as a traffic responsive system, diversions, etc.

3.13 Most UTC Systems use a mix of control strategy, both fixed time and traffic responsive systems to control and monitor traffic signals. Some areas may need the flexibility of traffic responsive control while other areas may be best suited with fixed time plans without traffic responsive control.

3.14 A secondary objective of the systems may be to provide the following additional facilities:

- i) Control and monitoring of signs to enable the implementation of diversions and provision of information to travellers.
- ii) Car park sign control.
- iii) Emergency vehicle priority through the provision of green wave timings on selected controllers.
- iv) Collection of traffic data.
- v) Congestion detection.
- vi) Public service vehicle priority through the provision of selective detection.
- vii) Provision of fault management.
- viii) Integration of remote monitoring equipment through interfaces.

3.15 The Authority should investigate their requirements and if appropriate specify them in the Works Specification along with: -

- i) Whether it is intended to have traffic responsive control in a new system from the start, add the facility at a later date, or add a traffic responsive system to an existing fixed time system;
- ii) The total number of junctions and signalled pedestrian crossings to be controlled. Both the initial number and the ultimate number based on a realistic appraisal of development over, say, the next ten years should be given;
- iii) Details of the number of stages at each installation and the fall back modes;
- iv) The total number of fixed time plans required. Most towns can identify a minimum requirement for four plans, these being typically AM and PM peaks, day time off-peak and night-time. Other plans for weekends or diversions may be identified. Modern UTC systems allow for forty more plans, but a practical limit to the number of plans that can be created and maintained would be around twenty. It is not necessary to provide data for all plans with the initial System Data;
- v) The number of sub-areas or traffic responsive system regions into which the whole area is to be divided;

3.16 Other facilities which may be specified but which may incur additional cost include: -

- i) The ability to impose fixed time plans on individual items of equipment;
- ii) The facility to reconnect automatically equipment which has been isolated due to incorrect message transfer bit reception; and
- iii) The facility to monitor for the absence of Vehicle Stage Confirmation for more than 60 seconds.

3.17 Inductive loop vehicle detectors are required to be sited on most links in a traffic responsive UTC area. Although the precise location of each loop is not required until during the contract period, effort by the Authority to site the loops early in the design stage both highlights any difficulties that may exist on certain links and enables the Authority to include in the Works Specification a preliminary loop specification, for which tenderers can provide comparative quotations. In addition, the Authority should determine what lengths of loop feeder cables are to be slot-cut and what lengths ducted, to the nearest OTUs. A schedule detailing which loops are to connect to which OTUs would be useful as the loop capacity for an OTU may vary between system suppliers.

3.18 Advice on siting SCOOT loops is given in MCH1352 "Technical Guide to SCOOT Loop Siting" but advice from existing users and system suppliers should also be sought. In general, the local Authority staff will not be able to define the position of all loops in the system. Therefore, the Authority should request a quotation from the system supplier for a loop siting survey to gain the benefit of the supplier's previous experience.

3.19 When validation is likely to take some weeks, an arrangement should be considered with the contractor so that some agreed minimum validation is carried out. This would typically be one region. The main contract should include this as a part of site acceptance tests of the systems and the remainder of the validation, if necessary, as a separate contract negotiated at a daily rate following on from system take-over.

3.20 Should the Authority decide to complete the validation itself a suitable training course should be purchased from the supplier and a separate visit by the UTC contractor, for a period at the end of the Authority's validation period, may be wise in order to sort out any unsolved tuning problems. The Authority should include an item for such a visit in their main contract.

3.21 It is clearly impossible to determine in advance how much time will be involved, though often fine tuning can be achieved within the time allocated for validation. Tenderers therefore may be asked to quote for an hourly rate for the job, combining validation with fine-tuning. During validation or fine-tuning of the system, it may be found that some loops could be better positioned. Experience has shown that up to 5% may require repositioning. A provisional sum should therefore be allowed in the contract to cover this contingency.

System size

3.22 Since a traffic responsive system requires more computing capacity than a fixed-time system, a computer suitable for operating a small UTC area may need to be changed, or linked to a second computer in order to provide traffic responsive UTC. Similarly, a system capable of controlling a given number of fixed-time intersections may not be capable of operating an equal number of traffic responsive intersections. It is not unusual to have a mix of traffic responsive and fixed-time installations in the system; the computer configuration required will depend on the proportions of each.

3.23 Different suppliers use different criteria for sizing purposes. However, system size is usually quoted in terms of either the number of OTUs, or the number of nodes (traffic signals including signalled pedestrian crossings). Both the initial system size and ultimate system size must be determined.

3.24 The capacity of available systems varies between suppliers. The Works Specification should clearly state the capacity required with any relevant information to allow the tenderer to offer the most practical configuration for the purpose. The system offered shall be designed to operate with minimum operator intervention.

3.25 In larger systems, multiple-computer or multiple-processor configurations may be considered. The area to be controlled may be divided into "cells" of 100-600 nodes. Each cell would then be controlled by a system as described above, modified as necessary to connect to a central management computer. Operator terminals may be switched between cells and the central computer using either hardware or software switches. A standby computer may be provided which can be used to replace quickly a failed computer. This could also provide facilities for regenerating the system and for off-line testing, etc.

Control Centre

3.26 Control Centres may be simple or elaborate in terms of accommodation and facilities, depending partly on the size and complexity of the system to be controlled, and partly on the requirements of the authority.

3.27 For fixed time or traffic responsive UTC systems it is recommended that the Works Specification includes:-

- i) A means of manual involvement in the automatic operation of the system.
- ii) A means of requesting output of certain system data (provided by a keyboard, PC and/or special control panel of push buttons and indicators).
- iii) A permanent record of faults and system operational events.

3.28 Two categories of audible and visual alarms to warn of:

- i) System alarm - associated with a system or equipment malfunction.
- ii) Operational alarm - associated with an operational condition e.g. timetable plan change due when manual plan is in operation.

NOTE: These shall be accompanied by separate visual indication and two distinct audible tones associated with the alarm category. A single control shall be provided to silence both types of audible tone. Whenever an alarm condition is generated, the system shall output an appropriate message indicating the reason for the alarm and the system time. A switch to disable the audible alarms may be called for in the Works Specification.

3.29 The system designer may consider providing additional control room facilities bearing in mind the level of manning proposed for the control room and the degree of operator manual involvement.

3.30 Such facilities are generally aimed at improving the presentation of system data to the operator and include:-

- i) A Wall Map, or video wall display in the form of a simplified diagram of the road network to provide system information such as:

faulty signals

activated queue detectors

diversions in operation, etc.

NOTE: It may be convenient to specify that the visual/audible alarms be incorporated into the Wall display.

- ii) A graphical user interface installed on a P.C is an alternative to the Wall display described above. This can provide a range of pictorial representations of the system, sub-areas or individual junction layouts, with data superimposed. Selection is by means of a keyboard. The user is usually provided with the facility to generate his own diagrams. More information can be obtained from suppliers.

NOTE: If a traffic responsive is being specified, the graphical user interface may also display certain system specific information. Other management visual displays may be available and the Authority should check with suppliers as to current availability of such programs.

3.31 It is sometimes difficult for a system designer to estimate the usefulness of a particular facility. In this case, the designer should obtain advice from, and visit, existing users to obtain the widest spectrum of opinion.

3.32 In general, the designer should beware of specifying something only one company can supply as this makes tendering difficult. All such special to contract features should be clearly defined as an option. Although many of these optional extras are very useful they may be expensive, particularly if they are tailor made, in relation to the actual benefit they provide and may make the system non-standard. The tender must be clear that these extras are optional if the Authority is likely to cancel some in view of costs.

Control Room Operation.

3.33 As a guide all UTC systems it is recommended that the Works Specification includes the following facilities:-

3.34 System operations shall normally be by time-table and shall include the following facilities:

- i) Introduction and removal of traffic responsive control (where provided).
- ii) Introduction and removal of fixed time plans.
- iii) Introduction and removal of diversion.
- iv) Opening and closure of car parks.
- v) Synchronise clocks and group timers.

3.35 In addition, the following operations shall be performed at nominated times.

- i) Output of traffic data.
- ii) Signal Controller routine testing.
- iii) The operator should be able to request the display of the plan change timetable(s) for any selected day.
- iv) Manual control shall be provided such that any of the facilities normally applied by timetable (i.e. plans, diversions etc) may be applied by operator command.
- v) The system shall have the capability restricting access to allow users different levels of control. (see clause 6.4 for more details).
- vi) It shall be possible for the traffic engineer to make temporary changes to plan and timing data. Temporary data introduced shall be stored in such a way that permanent data is not destroyed. It shall be possible to make temporary changes to the following data:

the timings of traffic stages;

the timetable switching points;

the cancellation or introduction of new timetable switching points;

offsets.

Any other changes should be given in the Works Specification.

4 DATA TRANSMISSION

General

4.1 This system provides the communication between the control computer and Outstation Transmission Units (OTUs) to which the equipment to be controlled is connected. A new type of OTU will be required for compatibility with UTMC (the intelligent OTU (IOTU)), and this can be supplied integral to new controllers.

4.2 The instation transmission equipment will be supplied and installed by the UTC Contractor. The instation equipment has to be compatible with the OTUs or IOTUs. Standardised data transmission protocols were developed as part of the UTMC research projects UTMC08 and UTMC09 and are being tested as part of the UTMC trials.

4.3 It may be possible for OTUs from several different manufactures to be controlled from the same UTC computer. Authorities are advised to consult the UTMC project team before specifying the data transmission requirements of their system.

NOTE: For the rest of this document it is assumed that OTUs and IOTUs can be regarded in the same manner, and that whatever applies to OTUs also applies to IOTUs.

4.4 The Authority should arrange to provide the transmission circuits and termination frame. The authority should consult with the telecommunication company early during the design stage since it is possible the company may have difficulty in providing the required circuits by the time the UTC contractor begins testing the system.

4.5 The UTC contractor will normally be responsible for the wiring between the line termination frame and the instation transmission equipment, and between the OTU and the local telecommunication company termination point. Note that it will be necessary to break the base seal of existing traffic signal controllers to install the additional cable(s). It may be preferable that the signal maintenance contractor breaks the seal, and reinstates after completion.

4.6 Signal controllers should be modified under separate contracts to provide them with an UTC interface and Remote Reconnect facilities if required.

4.7 The UTC contractor will supply cables fitted with plugs for connection to the OTU, which the Authority should arrange to have wired to the controller interfaces.

Instation Data Transmission Equipment

4.8 This equipment provides the interface between the computer and data transmission lines, and comprises logic circuits, modems and line transformers. The Authority should specify in the Works Specification the quantity of instation Data Transmission Equipment required, by specifying:

- i) The number of OTUs to be installed in the initial system (requiring full instation equipment).
- ii) Future system expansion requirements (in terms of OTUs and/or Nodes), which should be capable of being effected easily by the addition of plug-in units to the data transmission racks.
- iii) The proposed data transmission line configuration.

Outstation Transmission Units (OTUs)

4.9 The functions of an OTU are:

- i) To control outstation equipment by means of a number of output circuits set in response to a control message received from the UTC central computer.
- ii) To transmit a reply message containing information obtained from a number of input circuits to which the controlled equipment is also connected.

4.10 The control and reply messages that are used for UTC are detailed in TR 2210.

4.11 Different manufacturers have different approaches to the most economical use of both types of OTU.

4.12 It is important to determine the number and locations of OTUs required early during system design, since this information is needed to discuss the provision of transmission lines with the telecommunication company.

4.13 To determine the number of OTUs required first identify all items of outstation equipment to be connected to the initial system. The control and reply data bit requirements of each item may then be obtained using the glossary. If any additional monitoring facilities described in TR 2210 are required, these must be described in the Works Specification, as these may not be available from all system suppliers.

4.14 Once the bit requirement is known, equipment can be allocated to OTUs. Depending on the availability of bits, more than one item of equipment can be connected to one OTU. It may be necessary to carry out a cost benefit analysis of the whole life communication costs of providing separate OTUs compared with the costs of cabling linking the two controllers.

4.15 OTUs are most conveniently housed in traffic signal controllers, but separate cabinets are available if necessary. The Authority should specify the type of housing required for each OTU. An OTU can control all the items of equipment in its vicinity, subject to the number of control and reply bits available and duelling costs. The maximum number of bits provided by an OTU will depend upon the Manufacturer's OTU specification. It is a good design aim to try to reserve 25% of control and reply bits as spare capacity.

4.16 There are practical limits to the distance that street equipment can be cabled to an OTU. The Authority is advised to consult manufacturers if any such distance exceeds 150m.

Data Transmission Lines

4.17 Transmission lines are normally rented from a telecommunication company. The Authority is advised at an early stage, to discuss the technical requirements and specification of the data circuits with the system supplier.

4.18 Types of line configurations in common use are:

- i) Radial or point-to-point, where each OTU is provided with a separate fixed circuit to the control centre.
- ii) Multipoint, where several streetside communications units can be connected to a locally sited concentrator or Multi Channel Terminating Equipment (MCTE) although this may depend on OTU type and line type. Communication between MCTE and control centre is then by a single 4-wire circuit.

MCTE's may be provided by the UTC contractor or by the telecommunication company.

iii) Networked, where the telecommunications provider provides one-way links from his own equipment to each piece of street equipment and, separately, to the control centre. Networked solutions could be based on normal 'dial-up' telephone lines, or on specialist 'packet-mode' data circuits. Networked solutions do not offer the same degree of reliability as point-to-point or multipoint solutions, and may not be usable with some UTC applications.

4.19 The Authority should be aware that British Telecom no longer wishes to supply Multi-point circuits. They have agreed to continue to supply these circuits whilst they develop alternatives circuits but the annual rental costs of existing Multi-point circuits and any alternative circuits is likely to increase each year by more than the retail price indicator.

4.20 It is also likely that the rental costs of all analogue circuits will also rise significantly each year. These factors must be taken into account when comparing costs of different line configurations. The Authority should discuss the options with the telecommunication company, prospective system suppliers and the UTMC project team, as soon as the area to be controlled and the location of the control centre have been determined.

Traffic Signal Controllers

4.21 Electromechanical controllers must be replaced by microprocessor controllers. Existing solid state controllers to the obsolete specification MCE 0126 must be modified to provide an approved UTC Interface.

4.22 Controllers purchased in the past to MCE 0141 and MCE 0125 may have been supplied complete with an UTC Interface or may be retrofitted with IOTUs.

4.23 Microprocessor controllers to TR 2210 give a choice of operating strategies. These are defined in TR 2210. The difference being mainly in the significance of the stage force bit, in relation to its associated Demand bit, for control of demand dependant stages and the controller's response to the transmission of multiple Force bits.

5 IMPLEMENTATION

UTC System Data

5.1 System Data includes details of Fixed Time Plans, diversions, green waves, traffic count periods, format and units of the vehicle count output, signal controller stage sequences, maximum and minimum greens and inter-greens. For systems operating a traffic responsive strategy there are additional parameters defined in the system manufacturers traffic handbook. Many items of data may be easily altered either on a temporary or permanent basis with the system on-line. Other items are alterable with the system off-line or as a background function with the system on-line. The tenderer should be asked for details of the procedures for making temporary and permanent changes to the System Data.

5.2 The Authority provides System Data to the Contractor during the contract period. The latest date by which this information is required should be specified by the tenderer. The data is usually entered on proformas provided by the Contractor. The Works Specification should require that these forms are available to the Authority well in advance of the required return date. It may be beneficial to future operation of the system if the Authority's staff enter some of the data.

5.3 During the early part of the contract the Authority should make every effort to ensure that timings etc, recorded for traffic signal controllers, correspond with those set on street. Discrepancies between System Data and actual controller timings are often the cause of delays for the contractor during commissioning, which the Authority may have to pay for.

Collection of Traffic Data

5.4 Some traffic data may be available from traffic responsive UTC detectors if the ASTRID system described in clause 5.3.3 is specified. However such data is not available in fixed time systems and it is often necessary to install specific inductive loop count sites.

5.5 The number and locations of inductive loop count sites, and their configuration ("n", "n + 1" or 2n-1) should be specified in the Works Specification.

5.6 Where space is available, loop detector packs may be housed within traffic signal controller cabinets. If no space is available, or if the loop is sited too far from the controller, separate cabinets to house the detectors will be supplied by the contractor. The Authority should identify all detector housing arrangements in the Works Specification.

5.7 Some UTC systems may count all sites at all times. However, to save on computer storage, and subsequent long-term data storage by the Authority, the facility exists for an operator to select from a number of sites permanently connected to the system, those that are to be recorded. The Works Specification should specify how many sites are to be selected from the total number, for data recording. As a guide, a typical number of count sites for a medium size town would be 12 sites recording at a time from a total of 30 connected.

5.8 It should be possible for the accumulated traffic data to be output by a manual request. When such a request is implemented the traffic count data stores shall not be reset and the full count output shall be given at the normal time.

5.9 It is permissible to apply a scale factor, say up to 16 to the traffic count data (for example, a count may be registered for every fourth vehicle) and corrected back to their true values before output takes place.

NOTE: The storage requirements for all traffic volumes for 15-minute intervals during peak periods and hourly intervals in off-peak periods should be specified in the Works Specification. The start and finish times of such periods may be fixed in the site data but need not be coincident with the plan change times. It should be possible to set different peak times for each day of the week. The count information should be stored separately for each direction of traffic flow at each site. There should be provision for the storage of a vehicle count data in units of vehicles per hour of up to, say 2,000 vehicles in any count interval.

5.10 Even the typical number of sites quoted above will generate a considerable volume of data. The Authority should give serious consideration to how the data will be used, and decide the most appropriate output medium. Output of the daily summary (0000-2400 hours) at the selected sites shall be computed to give the hourly flow, the peak hours flow the daily 16 hour (0600-2200 hours), and 24-hour flow. This summary, in plain English tabular formation to be output to the control centre printer, or via a special output port to some other data storage device, or to another computer system for storage and analysis (specified by the authority). The Authority should discuss their specific requirements with potential tenderers to avoid problems of non-compatibility with approved systems.

5.11 The Authority may wish to discuss with potential tenderers methods by which traffic counts may be obtained from other detection equipment. The Authority is advised to establish the accuracy of such alternative methods.

Congestion, queues and incident detection

Queue detection

5.12 Detection of congestion may be based on queue detectors, which detect the presence of stationary vehicles for more than a pre-set period and/or occupancy detectors, which are used to give an indication of slow moving, congested traffic. The number of congestion alarms should not be greater than that which the operator could reasonably be expected to attend to during busy periods.

5.13 Congestion threshold values for each site should be specified in the Works Specification. Occupancy thresholds are normally stored in the UTC Computer and queue detector thresholds are normally set on-site at the detector equipment. The siting of these detectors needs careful consideration.

INGRID - INteGRated Incident Detection

5.14 INGRID is a real time automatic incident detection system that uses algorithms to detect incidents using information from detectors in the SCOOT traffic responsive system. Techniques have been developed to assess the effect of a detected incident on the network.

5.15 There are two algorithms used to detect incidents:

- i) One examines current traffic data for sudden changes in flow and occupancy. No reference data is required for this algorithm.
- ii) The other algorithm uses historic reference data provided by the ASTRID database. For all SCOOT detectors in the network a daily profile of the expected flow and occupancy in each 15 minute period is stored and automatically updated in the ASTRID database. The algorithm detects incidents by comparing the current traffic situation with that expected from the historic reference data in ASTRID. An incident is indicated if the conditions are satisfied for one minute.

ASTRID - Automatic SCOOT TRaffic Information Database

5.16 The ASTRID database system has been developed to use information from SCOOT to provide a historical background of traffic conditions. The system continuously monitors and stores traffic conditions for later retrieval and analysis. The system can also act as a reference against which to compare current traffic conditions.

5.17 SCOOT produces compressed data every minute in a non-standard format that requires modifications by the company supplying the SCOOT system. The data is transferred to ASTRID at regular intervals, then processed and stored in a form suitable for access by the database programs.

5.18 Previously an offline utility, TRL has developed ASTRID to operate on-line. This enables information on the current state of the network and the expected state of the network (based on historic data) to be accessible for use by other information or incident detection systems. Data displayed by ASTRID is either collected directly from SCOOT or calculated from stored information.

5.19 The user can access and display both types of data in the same way. This can be very useful in incident management.

Congestion Management Using Gating

5.20 Gating (also known as traffic metering) is a traffic management technique, which allows traffic to be relocated away from one or more congested links within a network.

5.21 Typically, gating is used to hold traffic outside of a town centre to maintain free movement of vehicles in the control area. It is hoped that, in keeping internal critical links relatively free of congestion, the network becomes more stable.

5.22 This has the following positive effects on public transport:

- i) bus journey times become more reliable.
- ii) buses will be able to enter links more easily.
- iii) buses will be able to pull out from bus stops more easily.
- iv) delay is reduced for buses.

5.23 Congestion management strategies for buses have also been developed using the “gating” facilities. Traffic is relocated on to one or more upstream links where it is more feasible to protect buses by physical bus priority such as a bus lane. Gating is provided with traffic responsive UTC systems and can be provided using fixed time systems.

Locations

5.24 The number and location of congestion detection sites should be specified in the Works Specification. As a rule, congestion should be measured only at sites where the operator (fixed time UTC) or the system (traffic responsive UTC) can be expected to take some action to alleviate the situation. Congestion information from key points in the network could give an indication of how well the system is operating even if the operators can take no action. It must be emphasised that traffic responsive systems will automatically make adjustments to deal with congestion and incidents and operator intervention must be avoided unless an incident or obstruction could have made the system’s traffic model invalid.

Car park information system

5.25 A Car Park Information system can reduce circulatory traffic flow in the network and increases Car Park utilisation. This can be done by continuously measuring the number of spaces available in each car park. Then automatically switching variable message signs to indicate car park status and direction information, whenever predetermined threshold levels of occupancy have been exceeded.

5.26 The equipment is connected to an OTU for transmission of car park status information to the central computer.

5.27 To enable the display of the appropriate state on signs remote from the car park, it shall be possible to introduce a time delay, between the receipt of data from the car park and transmission of the appropriate control messages to the car park signs.

5.28 The car park equipment may be supplied by the UTC contractor, or it may be possible to modify existing car park management systems to transmit accurate measures of occupancy to the central computer.

5.29 A separate car parking information system can provide more comprehensive facilities. Such systems can be linked to UTC Systems by means of the common database and strategy selection modules of the UTMC system.

5.30 Variable message signs associated with the Car Park system are usually the subject of a separate contract with one of the specialist signs manufacturers. The Signs Specification should ensure the signs can interface correctly with OTUs. The sign message/symbols are subject to a separate approval exercise. The Authority should submit sign designs to the Approvals authority, for approval before manufacture.

5.31 A car park information system as described typically has an optical or rotating prism sign elements, contained within larger static signs. While the car park is available, the variable sign displays a directional arrow. When the number of spaces falls to a predetermined threshold the sign is switched to display ALMOST FULL, and at a second threshold the sign is switched to display FULL and the direction arrow disappears. A fourth message may be considered which indicates that the car park is CLOSED.

5.32 It is important that the information presented maintains a high level of credibility. Early experience of car park sign control found it necessary to double-check a FULL status by requiring that a queue had formed at the car park entrance (sensed by a queue detector), in addition to the FULL threshold being exceeded, before a FULL signal is transmitted to the central computer.

5.33 Frequent and confusing changes can be prevented of the display on the car park signs by the introduction of a time delay between changes of occupancy state.

5.34 The display of the appropriate state on signs remote from the car park may also require a time delay between the receipt of data from the car park and transmission of the appropriate control messages to the car park signs.

5.35 In addition, to compensate for system errors, the car park attendant has the facility to locally calibrate the car park occupancy figure against a physical count of spaces.

5.36 If further facilities or a different method of control from the above are considered to be more appropriate then the Authority should specify in the Works Specification the function of any special control and reply signals that may be required.

Diversions

5.37 This facility provides for the controlled diversion of traffic by the use of variable message signs and can also be used to control tidal flow systems. These diversion signs may be "No Entry", "No Right Turn" etc., and informative signs displaying the reason for the diversion e.g. "Bridge Closed", "Road Flooded" etc., with appropriate diversion information. Signs not prescribed in the Traffic Signs and General Directions must be approved by the Approvals Authority before manufacture.

5.38 The provision of variable message signs is normally the subject of a separate contract with one of the specialist signs manufacturers. The signs specification should ensure that the signs can interface correctly with Outstation Transmission Units (OTU) for both control switching and the generation of a signal to confirm when the sign has been correctly operated.

5.39 Such a system has been installed in a number of places to divert traffic when bridges are raised. These have operated on a fixed time plan system, and special plans are automatically introduced whenever a diversion is implemented. The diversions can be manually selected from a location remote from the UTC centre, but operation from the UTC terminal or automatically by the UTC timetable would be equally possible.

5.40 A diversion may also automatically request or continue to operate on a fixed time plan (or traffic responsive control) on a sub-area, group of sub-areas or whole area. All sub areas associated with a single request shall have the same plan (or traffic responsive control) requested for them. The plan requested shall be appropriate to the implemented diversion at the current time of day. If the diversion changes or a timetable change becomes due then the system shall re-calculate and request the new plan (or traffic responsive control) appropriate to the diversion at that time.

5.41 The UTC Works Specification should specify:

- i) The number of diversion routes and locations of signs.
- ii) Where required, the facility to automatically implement a plan whenever a diversion is introduced.
- iii) Interface to request a diversion remotely over the data transmission system, through an operator interface, or by timetable entry.

5.42 When building the data for diversion routes the designer should ensure that: -

- i) To designate any sign(s) as essential to a diversion such that failure of the sign to confirm shall result in the cancellation of the diversion.
- ii) Whether a delay is required between the introduction or cancellation of a diversion and the implementation or removal of its associated plan as in (a) above.
- iii) Whether a delay is required between the introduction of a diversion and the operation of its associated signs.
- iv) Whether any sign associated with the diversion is to be classed as "essential" i.e. if the sign fails to confirm operation the diversion will be cancelled.
- v) It shall be possible to operate or cancel the signs associated with a diversion after specified delays from the introduction or cancellation of that diversion. Where this facility is required details shall be provided in the Works Specification.

Emergency vehicle priority

5.43 The Fire Service should be consulted during the design period to identify regularly used routes that would benefit from the Green Wave technique. The number of Green Wave routes, the number of controllers per route, the location of the push-button panel within the fire-station(s) and any special interface requirements should be specified in the Works Specification.

5.44 During the contract period, the Authority will be required to provide Green Wave signal timings to the contractor as part of the system data.

5.45 The timings are usually derived initially from time and distance diagrams using Fire appliance journey times obtained from the Fire Service, or by a survey. By plotting maximum and minimum journey times, a green wave "window" can be estimated, which allows for the clearance of any expected queue and the priority stage to be held, on green, for the required period along the green wave route. By allowing for minimum green and inter-green from the previous stage, the latest time for forcing the priority stage at each intersection can then be determined. Care should be taken at those installations with prohibited stage changes.

5.46 Fine-tuning will inevitably be necessary, which may be achieved by using private cars at first, then by trial runs with the Fire appliance.

5.47 Transmission of the Green Wave demand to the central computer is via an OTU. The Works Specification should state whether a Green Wave confirm reply signal is required. This signal is usually used to illuminate the appropriate fire-station push button while the Green Wave is being implemented.

5.48 Ambulance green waves are not recommended as the frequency of operation is too disruptive. However, it may be possible to provide operator activated facilities for escorted 'fast' ambulances travelling to casualty departments or regional medical centres. SCOOT version 4.2 or microsimulation techniques will allow more accurate modelling of the disruption caused to the general traffic than previous versions.

5.49 The operation of the Green Wave facility should be detailed in the Works Specification. MCE 0360 gives guidance on the clauses that may be required.

Local Controller

5.50 The system shall allow the operation of signal controllers that have been modified to allow for emergency vehicle priority.

5.51 A reply bit (EV) shall be provided from the controller to the central computer to indicate that a priority call is being served. The reply bit shall be given from the start of the emergency vehicle call signal, and shall cease at the end of that signal. Only one bit shall be provided, irrespective of the number of stages having emergency vehicle facilities. The system shall output on the operator interface and record in non-volatile form, the times of the start and finish of the receipt of the EV bit. The output shall also include a suitable descriptive message and the controller identity.

Synchronisation of real time clocks

5.52 Where this facility is required, it should be called for in the Works Specification and the signal controllers with real time clocks listed. All controllers must be on the same time synchronisation as the central computer.

Synchronisation of group timers

5.53 Where this facility is required, it should be called for in the Works Specification and the signal controllers with group timers should be listed.

5.54 Where called for in the Works Specification a facility shall be provided to enable group timers to be synchronised (set to the start of group 1) remotely to a predetermined set of offsets. These offsets shall be the same as those used to check that the signal controller group timer facility is operating correctly.

5.55 It shall be possible to synchronise all group timers at any time by operator command or by timetable event.

5.56 Synchronisation of a group timer shall be implemented by the transmission of the SG bit at Logic levels 0,1,0 in three successive scans to the relevant OTU. The last "0" will reset the group timer to the start of the first group. Offsets between controllers shall be arranged by the software such that the time between the system resetting the respective group timers to the start of group 1 creates the required offsets.

5.57 When synchronisation is not being attempted the SG bit shall be transmitted at logic "1" level.

5.58 If the Synchronisation Return (SR) bit fails to be returned within a predetermined number of consecutive scans in the range 1 to 8, a further two attempts shall be made to resynchronise at the appropriate times. After three consecutive failures, a system alarm shall be initiated and a suitable message output.

Staff training

5.59 In order to ensure that the Authority maximises the effectiveness of the system, the Contractor should be responsible for the training of the Authority's staff (and any persons nominated by the Authority) in the operation and appropriate maintenance of the system.

5.60 A sound understanding of how the system functions is essential to provide effective operation, even if all validation and re-validation is carried out by contractors, as and when necessary, problems can occur and not be diagnosed if the relevant staff do not have a good understanding of the system functionality.

5.61 Training will take place informally during factory acceptance and site acceptance as well as during formal training sessions and the Authority should ensure that the appropriate staff are present during these periods.

5.62 The training should cover all aspects of the system operation and maintenance, which will be carried out by the Authority. Due to the several interfaces between components, the ability to diagnose problems and identify the persons responsible for making the necessary repairs can contribute significantly to a high level of system availability.

5.63 In addition, a sound understanding of the functions provided would make a major contribution to the ongoing fine tuning and refinement of system operation, which are necessary. Tools and services, which are not used initially, may be found useful, as needs change. Good training will ensure that operational staff are fully aware of the functions, so that they can be used as and when appropriate.

5.64 The Authority is strongly recommended to discuss system operation and maintenance with experienced users, to gain an understanding of what is needed. In the UK, the TCUG (Traffic Control User Group) will provide valuable support.

5.65 The Authority should indicate the number of people who will be present during the various phases of training and ensure that appropriate facilities are available for those sessions, which are held on the Authorities premises.

Conditions of Contract

5.66 As a guide, copies of the Conditions of previous contracts could be sought from other authorities.

5.67 The General Conditions of Contract in use by Local Authorities can vary from one to another. It is recommended that a template of the most current Conditions of Contract be used. This will normally be supplied by the Local Contracts Department within your Authority.

NOTE: A document in common use is the Model Form of General Conditions of Contract (MF/1) (recommended by the Institution of Mechanical Engineers, the Institution of Electrical Engineers and the Association of Consulting Engineers).

Works Specification

5.68 After a general introduction on the scope of the works and related contracts the functional requirements of the system may be specified under the headings:

- i) System requirements
- ii) Control Centre
- iii) Data transmission
- iv) Signal controllers
- v) System data
- vi) System facilities
- vii) Special facilities
- viii) Acceptance testing
- ix) System documentation
- x) Staff training

5.69 The Works Specification should be accompanied by maps of the area, plans of the control centre and tables and lists giving details of variable sign aspects, signal controllers, etc.

5.70 It is convenient, and has become common practice, to have sight of previous Works Specifications for already installed systems when preparing a new one. The Authority should try to ensure, before obtaining such documents, that they are for systems of comparable size and complexity. In addition, they should understand why any special requirements were included and why, if any requirements of the Works Specification were not complied with by the system eventually purchased.

5.71 A note of caution however; the Works Specifications so obtained should be studied in the context of what was current at the time.

European Directives

5.72 The product shall comply with all relevant statutes in force at the time of supply, and particular attention is drawn to those implementing European Directives.

5.73 Any requirement of the specification for goods or material must be made in accordance with the general introduction and clauses 104 and 105 of Volume 1 of the Specification for Highways Works.

6 COMMISSIONING

Acceptance testing

6.1 Acceptance tests will normally be carried out both at the factory (Factory Acceptance Test, FAT) and on site (Site Acceptance Test, SAT).

6.2 The duration of factory acceptance tests will vary with system size and may be between 3 days to 2 weeks. They will use test data or site data (or a combination of both), as required by the Authority, to test as many of the facilities required in the contract as possible. The tests will be carried out with a representative selection of associated equipment.

6.3 Site acceptance tests should be of the full system, with all associated equipment incorporated, using the system data supplied. As a guide, at the end of this section, a check sheet is provided to help ensure that all system facilities have agreed FAT and SAT procedures.

6.4 The Authority should reserve a right for their representative to operate the equipment during the tests if desired.

6.5 The Contractor should be responsible for the provision of test equipment, programs, special data and any necessary simulators, which are required for the acceptance tests.

6.6 Test criteria should be specified, which the equipment must meet before it is accepted. These might be typically:

- i) The system is complete.
- ii) All tests and demonstrations completed successfully.
- iii) The system has operated correctly for a continuous period of 100 hours following SAT (including some validation).

Data Transmission Equipment

6.7 Generally, the transmission of data will be through a private wire system with well-accepted procedures to test the equipment.

6.8 The constant development of transmission techniques, enabling increased speed and reliability of data, will produce new test procedures. Differing transmission systems, through radio waves, fibre optic and coax cable may be used to suite different equipment. For example, a radio link to a remote VMS sign rather than a telephone line.

6.9 It is advised that for each transmission system adopted, the Contractor should be responsible for the provision of test equipment, test procedures, test documentation, programs, special data and any necessary simulators, which are required for the acceptance tests. This test equipment may also be required for maintenance purposes.

SCOOT Validation

6.10 SCOOT validation is the process of determining the values of SCOOT parameters by on-street measurement to obtain maximum agreement between the SCOOT model and on-street traffic behaviour throughout the day.

6.11 The Authority should ensure that system take over only follows a successful SAT and an initial validation period by the UTC contractor. A credible SAT should include a validated part of the network.

6.12 As a guide, validation requires a team of 3 people working (one at the computer centre, 2 on street) to cover both peak hours and day time off-peak, and takes on average about 2 days per node to perform. If the remote terminal is used, the personnel may be reduced, as there is no requirement for control centre staff.

6.13 When validation is likely to take some weeks, an arrangement should be considered with the contractor so that some agreed minimum validation is carried out. This would typically be one region. The main contract should include this as a set period as part of SAT and the remainder, if necessary, as a separate contract negotiated at a daily rate following on from system take-over.

6.14 Should the Authority decide to complete the validation itself, a separate visit by the UTC contractor, for a period at the end of the Authority's validation period, may be wise in order to sort out any unsolved tuning problems. The Authority should agree such visits with the contractor when planning the SAT Work Schedule.

6.15 Often the SCOOT database has initial parameters set which are supposed to define each junction/link.

NOTE: Authorities must not use SCOOT on-street immediately following receipt of the computer system, with these initial database values as these are not validated and are therefore inappropriate. However, the new system can be used after the SAT, which includes some validation of the system. Completion of link validation does not necessarily ensure SCOOT will achieve its optimum capability. Some fine-tuning of the system may also be necessary. The need for such tuning can arise, for example, because of compromises made when loops were sited, or to compensate for under-utilised fixed time stages.

6.16 It is clearly impossible to determine in advance how much time will be involved, though often fine tuning can be achieved within the time allocated for validation. During validation or fine-tuning of the system, it may be found that some loops could be better positioned. Experience has shown that up to 5% may require repositioning.

6.17 The Authority should try to avoid traffic management changes between loop siting and validation, as this will result in abortive system design and additional cost. Should on street changes take place e.g. lane marking, minor traffic management measures or, in the extreme cases, a change of priorities or one-way working then new data will be required to define the new street layout, within the database, before the system is re-validated and subsequently switched on. When the contractor is planning the SAT Work Schedule realistic time scales should be used.

Control Room

6.18 The Contractor should be responsible for the provision of test equipment, Test procedures, Test documentation, programs, special data and any necessary simulators, which are required for the acceptance tests.

6.19 The system shall have the capability restricting access to allow users different levels of control.

6.20 The normal access levels are as follows:

i) **Level 1 Control:** On level 1 control, the operator shall be able to carry out the control functions and display the related data.

ii) **Level 2 Control:** On level 2 control, the operator shall be able to carry out the functions and display the related data. All the functions available at level one shall also be available at level 2. Where temporary data has been introduced, it shall be used in place of the permanent data each time the plan, diversion, etc, to which it relates, is called into use. Where permanent data is stored in active or backing stores, it shall be possible under level 2 control to transfer all the data held in the temporary storage areas into the permanent storage by the input of suitable commands.

iii) **Level 3 Control:** On level 3 control, the operator shall be able to carry out all the control functions and display the related data.

6.21 The manufacturer may at his discretion provide other control and display functions which he considers necessary, either for operational or maintenance purposes. All such control functions shall normally only be available at level 3 unless otherwise agreed with the customer.

6.22 All system operations from whatever source which result in a change in the means of control of on-street equipment, e.g. plan change, introduction or removal of a diversion, shall be accompanied by a corresponding unsolicited message on the operator interface and recorded in non volatile form.

6.23 The data output shall provide the current data used by the system, i.e. it shall provide temporary data in place of permanent data where appropriate.

6.24 It shall be possible to return to the use of permanent stored data, either in total or item by item. This return to the use of permanent data shall be ordered such that the computer returns to the use of the permanent stored data and does not rewrite the permanent data into the temporary stored data.

6.25 Input messages shall be by either:

i) Entry through a graphical User Interface;

ii) keyboard entry in simple format in full English, abbreviated English, or mnemonic code provided it is simple and readily understood; and/or

iii) a logical control push button sequence which does not allow the inadvertent application of any control function, e.g. by provision of separate implement button etc.

6.26 Output messages shall be in simple format and can be in full English, abbreviated English or code provided it is simple and logical. In the case of all messages they shall identify the equipment concerned and where appropriate the type of fault and the time of occurrence of the event.

6.27 All messages shall be accompanied by the system time of occurrence.

6.28 Facilities shall be provided to enable the system time to be manually set.

6.29 At any time when the system is outputting any message, the operator shall be able to stop this output.

6.34 The SCOOT traffic handbook is standardised. The documentation provides details of the functional aspects of SCOOT and how to fully utilise its capability, including how to site loops, prepare a database and validate. This handbook should be obtained from the system supplier at the beginning of the contract. A good stage for this to happen is when the SCOOT licence is signed. The contract should be written to this effect.

6.35 Handbooks for other traffic responsive UTC systems should be obtained from the system supplier. A good time to obtain this is when the system license is signed. The contract should be written to this effect.

System documentation

6.30 The Authority should specify in detail the documentation required on the system and the storage medium on which it will be supplied i.e. hard copy, electronic data format on a compact disc etc. This should include the type of manuals required and the numbers of copies of each type to be supplied. Suppliers generally have a 'standard' set of documentation, which will have minor amendments to suit the Authority's System. The Authority is advised to ensure the documentation relates to the system, especially detail of special facilities.

6.31 The documentation would normally include:

- i) Operation Manual - description of all operator procedures, alarms, and system outputs.
- ii) Maintenance and Routine Service Manual - details of first line maintenance, routine servicing and operation of test equipment.
- iii) Design Document - Describes exactly how the supplier intends to meet the operational requirements of the system. Includes time-scale showing FAT and SAT dates.

6.32 Exceptionally, where a defined requirement exists, additional documentation could include:

- i) Systems Manual - overall system operation.
- ii) Equipment Manual - details of all installation and outstation equipment.

6.33 It will be necessary for the Authority to enter into a licence agreement with the supplier to operate SCOOT. The Authority is advised to request a copy of the licence with the tender return.

UTC Check Sheet:

Are Procedures Included for:	YES	NO	COMMENT
CONTROL SYSTEM			
System tests.....			
Systems data			
Printers.....			
Backup systems.....			
Alarms.....			
Other connected devices.....			
OPERATOR			
Keyboards.....			
Alarm acknowledgement.....			
Security and access control.....			
VISUAL DISPLAYS			
Operator consoles.....			
Graphical User Interfaces.....			
Alarms.....			
Wall maps.....			
OTHER			
Car Parks Equipment.....			
Priority.....			
Public Service Vehicles.....			
Diversions.....			
INGRID.....			
ASTRID.....			
Pollution Monitoring.....			
TRANSMISSION			
INSTATION EQUIPMENT TESTS (MAY BE INCLUDED IN SYSTEM)TESTS			
OUTSTATION EQUIPMENT (MAY BE INCLUDED IN SYSTEM TESTS)			
TELEPHONE LINE TESTS			
OTHER COMMUNICATION MEDIA TESTS (RADIO LINKS ETC)			

Continued	YES	NO	COMMENT
SITE			
TRAFFIC Functional tests.....			
CAR PARK Functional tests.....			
VMS Functional tests.....			
LOOP DETECTION Validation (where required) & functional tests.....			
OTHER TYPES OF (ABOVE GROUND UNITS Validation (where required) & functional tests.....			
OTHER			
Car Parks Equipment..... Functional tests.....			
Bus Priority..... Validation (where required) & functional tests.....			
Public Service Vehicles..... Validation (where required) & functional tests.....			
Diversions..... Functional tests.....			
INGRID..... Functional tests.....			
ASTRID..... Functional tests.....			
Pollution Monitoring..... Functional tests.....			

7 MAINTENANCE

Maintenance Specification

7.1 After the successful completion of SAT on the system and system components, maintenance agreements should have been agreed to start consecutively.

7.2 As a guide, the maintenance of the UTC system and system components will normally be the subject of separate contracts. The only exception to this will be the system software, which can only be maintained by the system supplier. The equipment to be maintained must be specified, and is normally the equipment included in the supply contract. The maintenance of rented telecommunication lines, electricity board cable repairs and painting of the roadside equipment should not be included.

NOTE: With the reliability of modern computing equipment, there should be no necessity for a maintenance service to be provided on the in-station equipment outside normal working hours, or possibly outside the hours during which the control centre is manned.

7.3 For outstation equipment, a service in accordance with the current standard classes of maintenance should be provided for traffic signal controllers.

7.4 Faults on the system may be classified as urgent or non-urgent. Urgent faults, which would require the emergency action response, would include:

- i) Any control office faults causing loss of system control.
- ii) Data transmission faults involving more than 4 OTUs.
- iii) Equipment damaged.
- iv) Equipment in a dangerous condition.

7.5 There is no standard form of maintenance agreement for UTC systems as there is for traffic signal installations, but a similar philosophy should be adopted for UTC system maintenance as for signal maintenance. The maintenance requirements may approximate to one of the standard classes of maintenance, with similar attendance times and rebates for non-performance.

7.6 The Works Specification should require the Contractor to:

- i) Be responsible for maintaining a fault record. This should include details of all visits to the control centre or outstation equipment, faults found and action taken.
- ii) Be required to have approval from the Authority before he can suspend system operation to run diagnostic programs or carry out other faultfinding procedures. This will ensure that the system is not disconnected during critical periods. The contractor should not be penalised if this approval is refused. The Contractor should also obtain approval before running any tests that could cause significant disruption of traffic.
- iii) Be responsible for locating the faults, informing the appropriate organisations for all equipment not covered by the contract. As it is impossible for a contractor to estimate the cost of carrying out these duties in respect of equipment for which he is not responsible, any work carried out on this activity should be at rates specified as being additional to the contract price.
- iv) Report to the Authority all faults that occur repeatedly on equipment with "no fault found". The Authority should reserve the right to order a special investigation by the Contractor, with the Authority's representative in attendance.

NOTE: The cost of this investigation should be borne by the Contractor if the reported or if a related fault is discovered, and by the Authority if no fault is discovered, or the fault is outside the responsibility of the Contractor. The Authority should provide the Contractor with a list of the appropriate maintenance organisations for all equipment not covered by the contract.

8 GLOSSARY

Area: First in the SCOOT hierarchy. The SCOOT Area contains one or more Regions, each of which contains a number of nodes. Area data is required as input as part of the set-up of a SCOOT network.

ASTRID: Automatic SCOOT Traffic Information Database. ASTRID is a database designed to collect information from a SCOOT traffic control system, or other source of traffic data, and to store it in a database for later retrieval and analysis.

Automatic Vehicle Location (AVL): AVL systems are used to help give bus priority in SCOOT. With AVL, buses are fitted with equipment that determines bus location. The bus transmits its identifier and location by radio when it is polled (interrogated) from the central unit.

Bit (Control): An element of data in a control message, which is allocated a specific function, and identified by its position in the control message. The Standard control bits are described in TR2210.

Bit (Reply): An element of data in a reply message that is allocated a specific function and identified by its position in the reply message. The standard reply bits are described in TR2210.

Bus priority: Bus Priority is a facility whereby buses can receive priority benefits at controlled traffic signals to reduce delay. It can be provided directly in SCOOT and either locally or through other systems in fixed time UTC. Buses can be given extensions where the green is extended, allowing the bus to continue or recalls where a bus is detected on a red causing other stage times to be reduced, in order to bring forward the green onto that link.

Control Mode: The method of operation of a traffic signal controller, i.e. under computer control, group timer control, vehicle actuation, manual or fixed time control.

Control Message: A series of control bits organised into words or characters, transmitted from the UTC control centre to the Outstation Transmission Unit, containing administrative information and control data.

Congestion: A traffic parameter relating to the density of traffic on a given length of road.

Congestion (SCOOT): This parameter is expressed as a proportion of the "Cycle time", using the number of 4-second intervals within a "Cycle" during which the detector is continuously occupied.

Control and Monitor Terminal: Device by which an operator can control the system and by which the system can display information.

Cycle / Cycle time: The length of time in seconds for a complete stage sequence to run before it is repeated.

Default Value: A value which can be used when faulty detectors prevent normal SCOOT calculations with online data.

Demand Dependant Stage: A traffic signal stage that will not appear unless a demand for the stage exists from street detectors or computer 'D' bits.

Divers ion: An alternative route which can be identified by a series of variable signs.

Double Cycling: Facility to allow nodes to operate at half the region cycle time. Reduces delay at lightly loaded junctions within a region that requires a longer cycle time.

Factory Accepted Test (FAT): An acceptance test for the system carried out at the manufacturers' factory.

Fixed Time: A mode of operation of a traffic signal controller here each stage normally runs for a predetermined constant period.

Fixed time plan: These are pre-determined signal plans brought into use under appropriate traffic conditions. Usually the plans are selected by time of day, this being the most accurate predictor of likely traffic conditions in the immediate future.

Flow: The amount of traffic movement along a link.

Gating: It can be used to restrict traffic from entering or leaving a critical area.

Green Wave: A special set of timings imposed on a series of signalled junctions to aid the progression of emergency vehicles.

Group Timer: A device installed in traffic signal controllers that stores a fixed time plan and which incorporates an accurate clock, enabling the local synchronisation of signals.

Incident: An incident is an event that reduces the capacity of a network link to carry traffic.

INGRID: INteGRated Incident Detection. A computer program for the automatic detection of traffic incidents in urban areas controlled by SCOOT.

Instation: The instation is that equipment which is connected between the input and output (or the communications interface) of the computer and the communication line circuits.

Intergreen: The period between the disappearance of right of way, to one stage of a signal controller, to the start of right of way to the following stage.

Link: A symbolic representation of a length of road terminating in a Traffic Signal Stop Line, where all traffic on the link receives the same signal.

Link (SCOOT): A length of road from the SCOOT detector to the stopline. More than one link is specified on a stretch of road if their movements are separately controlled at the junction i.e. right turning traffic has different signal requirements to a straight ahead.

Linked Operation Node: A node is an intersection of competing Synchronised operation traffic streams where precedence is determined by a variable aspect traffic control device.

MOVA: (Microprocessor Vehicle Actuation) is a modern microprocessor technology developed by TRL for isolated intersections to optimise signal timings.

Network: Is the layout of nodes and links in a region; the network of roads controlled by the system.

Node: Third in the SCOOT hierarchy. A node is a set of traffic signals in a SCOOT region.

Normal link: Normal links are those that join one node to another in a network.

Occupancy Detector: A loop detector that is sampled several times per second, over a defined period, for occupancy of the loop by a vehicle. Thus

enabling the percentage of time occupancy to be determined.

Offset: The offset on a link is the time between the start of green to the main feeder link at the upstream link, to the start of green to this link at the downstream node.

Optimise: To provide the best possible signal timings.

Optimiser: A SCOOT program which incorporates an algorithm to calculate the optimum current value for the relevant parameter.

Outstation: The Outstation comprises outstation Transmission Unit (OTU) together with any Traffic Control Equipment that is connected to the OTU.

Outstation Equipment: Equipment installed on-street to be controlled by the UTC computer.

Outstation Transmission Unit (OTU): An item of equipment, which interfaces the equipment to be controlled, with the UTC data transmission system.

Parity: At least one bit in each Control message shall be used for the parity check.

Plan: A set of control timings for one or more items of equipment to be controlled.

Queue: A number of vehicles delayed at a node.

Queue Detector: A loop detector arrangement which gives an output if the loop is occupied by a vehicle continuously for a predetermined period.

Region: Second in the SCOOT hierarchy. A SCOOT Area has one or more regions in which there are a number of nodes. All nodes in the region operate at the same cycle time, or possibly half of the region cycle time - see **Double Cycling**.

Remote Reconnect: An optional OTU facility to manually re-establish UTC control of equipment remotely. This reply function is usually provided by a mechanical switch or as a function of a TR2210 controller.

Reply Message: A series of reply bits organised into words or characters transmitted from the Outstation Transmission Unit to the UTC computer containing administrative information, confirmatory data and traffic and SCOOT data.

Sampled Data: Sampled data are reply message data created in the OTU by scanning one or more inputs at a rate of 4 times per second to produce 4 bits of data for each input.

Saturation Occupancy: Maximum outflow from a stopline in the SCOOT model measured in SCOOT units.

SCOOT: The SCOOT (Split Cycle Offset Optimisation Technique) urban traffic control system was developed by TRL in collaboration with the UK traffic systems industry. SCOOT is an adaptive system, which responds automatically to traffic fluctuations. It does away with the need for signal plans, which are expensive to prepare and keep up to date. SCOOT has proved to be an effective and efficient tool for managing traffic on signalised road networks and is now used in over 130 towns and cities in the UK and overseas. It has demonstrated a range of Journey Time benefits averaging at about 25%.

SCOOT hierarchy: Data needs to be entered into SCOOT at different levels. The basic SCOOT hierarchy states the different levels available:

Area > Region > Node > Stage > Link > Detector

Site Acceptance Test (SAT): A system acceptance test carried out when the system has been installed at its operational site.

Split: The proportion of green time given to a particular stage within a cycle.

Split optimisation: The split optimiser decides the optimum distribution of green time to minimise delay and congestion. It considers one node at a time.

Sub-Area: A group of traffic signal installations in UTC area, which normally operate under the same cycle time.

Terminal: That equipment that is connected to each end of a communication link.

The Authority: The Authority means the body who places the contract with the manufacturer.

The Approvals Authority: The Highway Agency.

Traffic Control Equipment: Traffic Control Equipment is any equipment that is on the street and is used for traffic control purpose, e.g. traffic signals, signs, detectors, etc.

TRANSYT: TRAFFIC Network Study Tool is a TRRL developed program for calculating the 'best' fixed time plan with which to co-ordinate the traffic signals, in any network of roads for which the average traffic flows are known. Demonstrated Journey Time benefits of between 15 and 20%.

Validation: Is the process in the SCOOT system set-up where on-street data is compared with information from the SCOOT model.

Variable Message Sign: A sign which can be altered (usually remotely) to present different messages.

(VA) Vehicle Actuation: A mode of operation of a signal controller where stage changes and stage durations are controlled by vehicle detectors.

Vehicle Detector: Any device, usually an inductive loop, which can distinguish the presence or absence of a vehicle

9 REFERENCES

9.1 This document incorporates by dated or undated reference, provisions from other publications.

British Standards:

BS 7671	Requirements for electrical installations (The IEE wiring regulations).
BS EN 60529	Specifications for degrees of protection by enclosures (IP Code).
EN 50293	Electromagnetic Compatibility – Road Traffic Signal Systems.

Specifications and Instructions:

MCE 0123	Emergency Vehicle Automatic Detection Equipment.
MCE 0304	Computer centre equipment.
MCE 0312	Data Transmission System Traffic Control.
MCE 0360	Urban Town Traffic Control - Functional Specification.
MCE 0361	High Capacity data transmission system for use in UTC.
MCH 1352	Technical Guide to SCOOT Loop Siting.
MCH 1542	Installation guide for MOVA.
MCH 1932	Vehicle Detection Techniques.
TR 2210	Microprocessor Based Traffic Signal Controller.
TR 2029	Inductive Loop Cable for Vehicle Detection Systems.
TR 2031	Armoured Feeder Cable for Inductive Loops Systems.
TR 2130	Environmental Tests for Motorway Communications Equipment and Portable and Permanent Road Traffic Control Equipment.
TR 2206	Traffic Signals for Road Traffic Signals.
TRG 0500	Statutory Approval of Equipments for the Control of Vehicular and Pedestrian Traffic on Roads.

Other Publications:

DTLR	Traffic Advisory Leaflets 07/99. The “SCOOT” Urban Traffic Control System.
MPT1337 DTI	Performance Specification for Low Power Induction Communication and Control Systems Operating at Frequencies up to 315 kHz
The Department of Trade and Industry (DTI)	Radio Communications Division, in respect of Performance Specification MPT 1337 for Low Power Induction Communications and Control Systems.
	Department of Transport 7th Edition of the Specification for Highway Works, Volumes 1 Series 1200 & 1500, Volume 2 - Notes for Guidance NG1200 & NG1500 and Volume 3 - Highway Construction Details (HCD) G series drawings, HMSO publications.
SCOOT Traffic Handbook.	Part of the supplied SCOOT System Documentation. It is available only to the holders of a SCOOT licence.

Contacts and Information for UTC and SCOOT.

Web site <http://www.scoot-utc.com>

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Contacts and Information for UTMC

More information may be obtained about this from:

UTMC Programme Office

Website: <http://www.utmc.org.uk>

The following specification documents can be retrieved from this site:

- Part 1: Infrastructure (Adobe Acrobat - 101kb) sets out the essential infrastructure for UTMC systems in terms of functional and logical reference models, the key elements of systems and the data transfer standards.
- Part 1: Communications (Adobe Acrobat - 152kb) revises and supersedes the provisions of TS001 (Part 1: Infrastructure) pertaining to communications services.
- Part 2: Data Dictionary (Adobe Acrobat - 712kb) defines the structure and meaning of the data used in UTMC systems.
- An Introduction to the Technical Specification for UTMC Systems (Adobe Acrobat - 39kb) provides a brief (15 page) introduction to UTMC.
- Technical Issues (Adobe Acrobat - 791kb) detailed (120 page) technical explanation of the requirements of the Specification and discusses some of the issues their application will raise.

Deliverables from all UTMC projects are also posted together with newsletters and details of forthcoming events.

10 HISTORY

MCH 0010 A Draft March 1978.

MCH 0010A Issued September 1978.

MCH 0010 B Draft April 1984.

MCH 0010 B Issued July 1984.

MCH 0010 C Draft January 1989.

MCH 0010 C Issued January 1990.

MCH 0010 D March 2002

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