RTIG

UK Real Time Information Group

On-vehicle systems architecture

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1 Introduction

1.1 About this document

1.1.1 RTI equipment is equipped to over 50% of all buses in the UK fleet. In many cases, fitting equipment and cabling can prove to be a time consuming and expensive endeavour. This document provides cabling and connection details for bus builders that will allow bus operators to select and fit RTI equipment in a relatively short time-frame, as well as feeling confident that any equipment that they wish to install will have the appropriate cabling and connectors.

1.1.2 What this document is not is a specification for an equipped bus. It only provides bus builders with cabling and connector details so that bus operators can install RTI equipment as appropriate.

1.2 Document structure

1.2.1 The document begins with a brief description of the scope of the document and the nature of the architecture under discussion.

1.2.2 Following this, cabling and termination requirements for each piece of on-board equipment is outlined in detail. This should enable bus-builders to prepare new buses for equipment installation. Where necessary, location information is also given, especially for areas which are key to the overall architecture.

2 On-vehicle architecture

2.1 Introduction

2.1.1 Bus operators and bus builders alike have expressed a desire for a clear, common agreement on what to specify at the point of procurement, so that the bus is provided with a pre-installed framework of facilities into which electronic equipment may easily be slotted – either by the bus builder at the point of sale, or by the operator subsequently.

2.1.2 The requirement for open standardisation comes from three sources:

- Operators are likely to want to use common equipment across their fleet. They therefore want comfort that their chosen supplier's kit will fit into the bus builder's framework with the minimum of disruption.
- Operators may need to follow the requirements of local authorities in implementing particular technologies (particularly in London but to an extent elsewhere too). They may have little control over the timing and vendor for these equipment buys.
- Critically, larger groups wish to rotate buses from one local area to another. This may require the deinstallation of one set of equipment and the reinstallation of a second set. It is essential that this process be as simple as possible, for reasons of cost, time, and in some cases the structural integrity of the bus (eg avoiding too much metal-cutting).

2.1.3 This section outlines the general approach taken in this Specification.

2.2 Procurement strategy

2.2.1 It is envisaged that this Specification should be applicable to as wide a range of bus builds and procurements as possible. It has therefore been designed to be flexible.

2.2.2 Specifically *everything is optional.* It is up to the operator to determine which aspects of this specification to use, and how much to vary any individual part of the specification as given here. Not all buses will need all facilities.

2.2.3 However, it is likely that is will often be better to buy more facilities than immediately required, to make the bus easier to equip later on. It is recommended that bus operators seek to include in their procurement specifications:

- a cabinet for a central computer;
- a suitable set of pre-installed point to point ducting and wiring;
- a suitable set of pre-installed points where vehicle information is electronically delivered.

2.3 System scope

2.3.1 Buses have been fitted with more and more systems in recent years, and this trend may continue in future. However the base set of equipment which is likely to be used reasonably frequently is fairly clear, and is likely to be robust for a while yet.

2.3.2 On this basis, the Specification covers the following:

- Voice radio (driver microphone, driver speaker);
- Driver display unit;
- Emergency/Panic button;
- Push To Talk button;
- Electronic Ticket Machine (ETM);
- Traffic Light Priority Radio;
- Next-stop display;
- CCTV (including internal and external cameras and recording equipment);
- Advertising;
- Vehicle diagnostic systems;
- Public loudspeakers;
- Odometer;
- Ignition signal;
- Vehicle stopping;
- Door signal;
- Common antennas;
- On-board computer;
- Wiring network;
- Passenger counting systems.

2.4 Architecture

Physical

2.4.1 The physical aspects of architecture are principally concerned with:

- The location and space provided for the on-board computer;
- The position of end points for the wiring system and the connectors used;
- The position of vehicle electronics feeds (eg ignition) and the connectors used;
- The cab layout.

2.4.2 This Specification covers the first three of these. The last is regarded as too closely tied into individual operator requirements, and is a matter for discussion with operators' cab committees etc.

2.4.3 The bus builder should normally expect to provide ducting and wiring, suitably sealed, but no wiring connectors. In some cases (specified) the bus builder may provide a bare duct with a drawstring only.

2.4.4 Bus manufacturers should make sure that all cabling is suitably tested for continuity and shorting before the bus is handed over to the operator.

Electrical

2.4.5 The electrical aspects of architecture are concerned with:

- Power feeds;
- Signal characteristics (eg for odometer);
- Impedance (eg for loudspeaker networks).

2.4.6 In addition wiring regulations will apply on aspect such as earthing, waterproofing etc. These are regarded as wholly within the bus builder's domain and are not specified here.

Communications

2.4.7 There are two types of equipment envisaged:

– Equipment which requires essentially a data interface; these are to be connected using an on-board LAN based on IP over industrial ethernet wherever practical. In some cases alternate or secondary datacomms systems may need to be used, specifically including RS485 for ticket machines which are not IP capable.

– Equipment which requires essentially a non-data interface; these will need to be connected to the on-board computer via a suitable 'patch panel' to allow monitoring and control. It is envisaged that the on-board computer supplier will normally provide this patch panel.

2.4.8 The diagram below indicates the architectural overview schematically, with a limited set of equipment. Note that the bus builder has full control over how the network and wiring runs are configured; the only constraint is on their exit points.

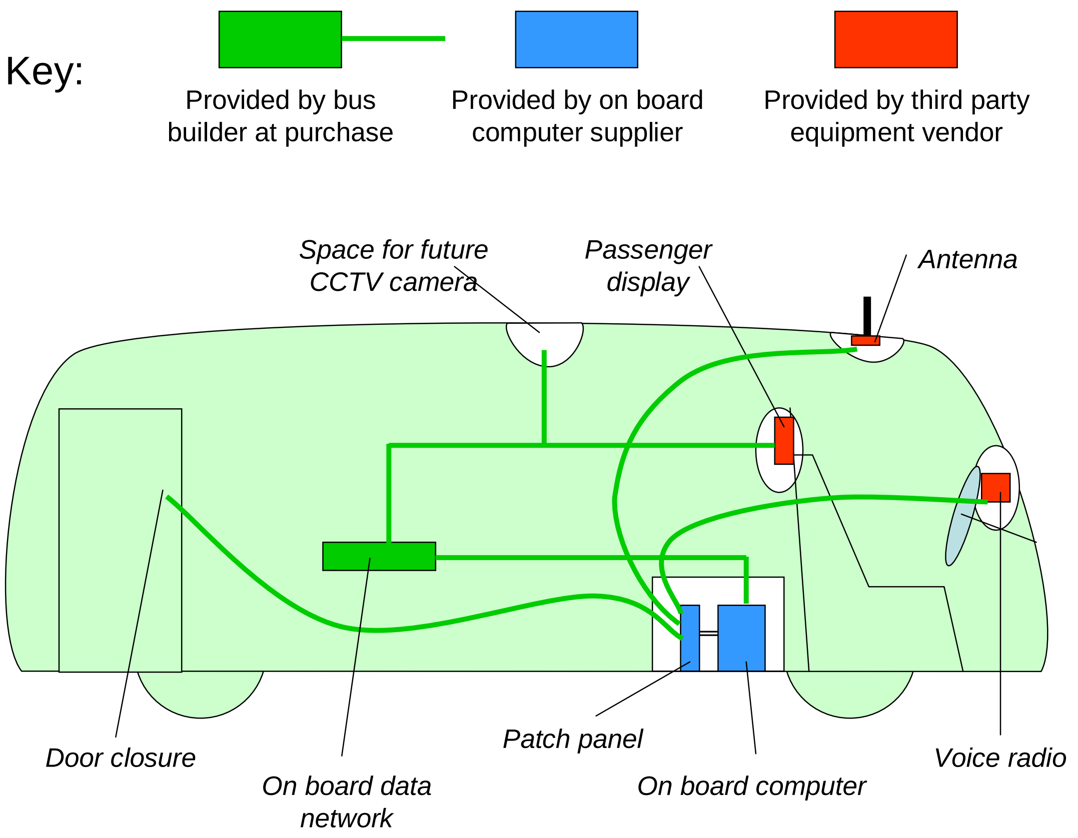


Figure 2-1: on-board systems – schematic of a typical architecture

2.5 On-board cabinet

Dimensions and construction

2.5.1 A secure clean cabinet space should be provided for the on-board computer. This should be capable of housing two standard 19″ industrial PC racks at least 3 units high, allowing for 100mm air space all round.

2.5.2 Taking into account the size of current on-board computer technologies, the recommended size for the cabinet is: 400mm (height) x 400m (depth) x 680mm (width). This will allow for the accommodation of two standard 19″ industrial PC racks and any CCTV recording facilities that the bus operator may specify, as well as the necessary ventilation space to ensure that temperature rises do not become excessive.

2.5.3 Ideally, the cabinet should be made from vibration proof material and any rack mounts should be constructed to cope with heavy equipment.

2.5.4 Cabinets should be able to withstand pressure washing. This may mean locating the cabinet away from any internal guttering.

2.5.5 There should also be an earth plate, earthed to the bus chassis.

Maintenance access

2.5.6 The space area must be easily accessible for maintenance purposes. It should also be located alongside the terminal block. All connectors should be easily accessible.

2.5.7 All connections come from the on-board computer, it is therefore important that consideration is given to easy cable access. An electrical patch panel which receives non data signals ("terminal block") will need to be located nearby, with a maximum wiring distance of at least 2m.

2.5.8 Feeds to this cabinet should be provided from:

- The on board data network;
- Required antenna cables;
- Required cables from third part non-data equipment;
- Required cables from automotive equipment.

2.6 Power supply

2.6.1 A power supply must be available to all relevant devices and should be either a 10amp permanent supply (with means to isolate for maintenance purposes) or an isolated power supply routed through the ignition. Permanent power sources will be required if wireless LAN equipment is installed for overnight download/upload purposes – this will depend on what equipment is specified. However, some bus operators may prefer to use an ignition supply in order to ensure that batteries do not go flat in the event that the system does not turn itself off.

2.6.2 The default provision is for 24V DC, and it is up to equipment providers to ensure that their systems can use (or adapt) this power source.

2.6.3 For most system components, the current draw will be small. The only common exception is public address: loudspeakers can take considerable current and a large vehicle (double decker or bendy-bus) should allow for up to 10A when the PA is activated.

2.6.4 All equipment fitted to the bus should have a sleep mode as standard.

3 Provision for individually wired systems

3.1 Introduction

3.1.1 The architecture outlined in the previous section means that each device within the scope needs to have described a physical and electrical interface. This section provides that for the main non-data systems.

3.1.2 Generally, these systems will require the bus builder to provide either direct wiring or ducting with drawstring.

3.2 Antenna mountings

Wide area (rooftop)

3.2.1 Antennas are required for wide area communications, for GPS positioning, and sometimes also for depot radio LANs. Wide area communications is normally VHF Band III or GPRS, but might also be WiFi (eg where there is a city-wide mesh network) or 3G.

3.2.2 Antennas are traditionally fixed to the roof of a bus. Where the bus roof is non-metallic, a metal groundplane should be provided. The preferred position is on the front offside of the bus. The groundplane should be at least 1.5m wide and 1.5m long to provide space for multiple antennas with non-interference. The groundplane should be bonded to the chassis.

3.2.3 There should be two access points (front and rear) in the antenna area, connecting to a cable channel suitable for up to 6 cables. The channel should run to the on-board cabinet and should be provided with drawstrings.

3.2.4 Bus builders should consider providing mountings and cable space for four standard antennae, in addition to the traditional analogue antenna. These antennae, and their specifications, are described in Appendix A.

Short range

3.2.5 In some cases it may be appropriate to mount antennas elsewhere: for example, short-range communications for traffic light priority and sign cleardown.

3.2.6 TLP equipment should be mounted in a location in front of the bus either in the blind compartment or any other compartment nearside the blind box. The antenna should point vertically as the receive antenna mounted at streetside will normally be vertically polarised. The space required for a TLP antenna is 300mm by 150mm.

3.2.7 A 6-way twisted pair cable (20AWG (0.5mm^2) minimum) should run from the antenna mounting space to the on-board cabinet. If the radio is mounted centrally (i.e. not in the cabinet), the cable should be replaced with coax.

3.2.8 The antenna location should be easy accessible and obstacle free, and should not attenuate the radio signal by any metal enclosure. If a bus type has an enclosed (metal cased) destination blind that takes up almost all of the destination blind area in the front of the bus, it will be impossible to mount the TLP radio in this area such that the RF transmissions have an unobstructed path through the destination blind glass. In such a case the operator needs to provide another suitable alternative location.

3.3 Driver voice communications

3.3.1 Driver voice communications are covered by the general rule that the operator's cab committee will have an input into location and design. These specifications are therefore starter suggestions only.

Microphone

3.3.2 Driver microphones are often mounted above and slightly to the front of where the driver's head would be. Alternatively, a goose neck type microphone can be used which the driver can adjust to his needs.

3.3.3 The microphone should be provided with a 2-core shielded twisted double cable to the on-board computer unit. Output is also required, as some microphones will have PTT buttons fitted.

Driver speaker

3.3.4 The driver speaker should be placed so that the driver can hear messages, but not so close to the microphone so that it creates feedback. Speaker position and volume should be adjusted if necessary prior to service commencing.

3.3.5 A twisted pare single cable (20AWG minimum) is required, but this may depend on the type of radio specified.

Voice radio

3.3.6 The radio unit may be mounted in the on-board cabinet. It will have three cables:

- Power cable;
- Antenna cable from the communications antenna(s), normally with BNC connecter;
- Data interface cable from on-board computer with industrial Ethernet connection.

3.3.7 The radio unit can also be mounted outside of the cabinet. If so, ensure that sufficient ducting and cabling is provided for connecting to the on-board computer.

3.4 Public loudspeakers

3.4.1 A bus should have the optimum number of loudspeakers to allow all passengers to hear announcements. For a double-decker bus it is recommended that each deck has six loudspeakers (twelve in total), in an articulated bus nine speakers is recommended and in a single deck bus six.

3.4.2 Speakers should be mounted in such a manner that acoustics are not spoiled in any way. Flush mounting speakers would be preferable as they are less prone to vandalism and sabotage.

3.4.3 Impedance matching is important. Bus builders should assume that each speaker presents a load of 4Ω, and the circuit should be designed so that the combined load at the amplifier is between 4 and 8 ohms. The wiring diagrams below indicate how series and parallel connections may be combined to achieve this.

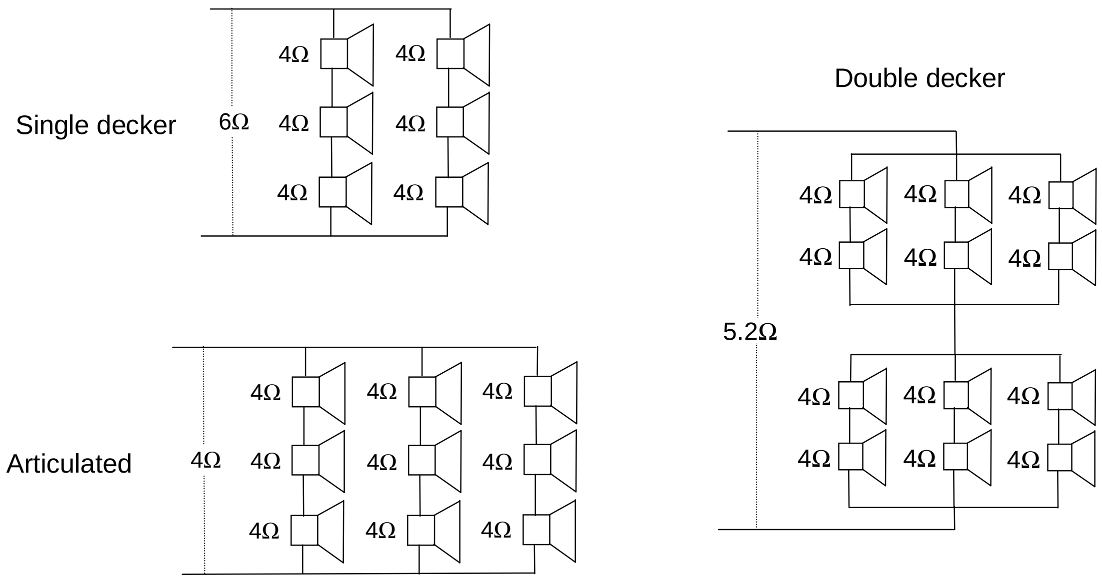


Figure 3-1: loudspeaker circuits – typical wiring schemes

3.5 PTT Footswitch

3.5.1 Footswitches are used to control voice radio communications. The footswitch can be mounted for either left or right foot operation and for heel or toe operation.

3.5.2 The footswitch housing will screw into the floor of the bus cab and a single cable should run to the on-board cabinet.

3.6 Emergency button

3.6.1 The driver's emergency button will often be placed in a covert place in the cab, within reach of the driver. A single cable should run into the on-board cabinet.

3.7 Vehicle stopping request button

3.7.1 'Bus stopping' is displayed when a passenger has pressed a request to stop button. This signal has to be a negative signal (0 VDC) when on and has to go off when the door is closed (24VDC). The signal is a voltage sensing input to the on-board computer and therefore has no current requirement.

3.7.2 The vehicle stopping request button signal requires a single cable to the cabinet.

3.8 Destination blinds

Front sign

3.8.1 The front sign should be mounted as close as possible to the vehicle window, and located above the vehicle windscreen.

3.8.2 The physical envelope required for installation of the front sign must be 1520mm (length) x 335mm (height). The minimum visible display area of the sign must be 1490mm x 252mm. The window in front of the display sign must have masking which conforms to these dimensions.

3.8.3 The sign must be supported by brackets attached to either end of the sign. The sign should also be supported at its bottom along it's length and preferably at the top along it's length also.

3.8.4 Power feed to the controller should be 24 D.C supplied on 16AWG (1.5mm^2), 2 core cable. Communication to the controller should be supplied on 20AWG (0.5mm^2), 2 core cable and typically via a RS485 interface.

Side sign

3.8.5 The side sign should be mounted as close as possible to the window on the near side of the vehicle adjacent to the front vehicle doors.

3.8.6 The physical space envelope required for installation of the front sign should be a minimum of 946mm x 185mm. The sign must be mounted at a height of not less than 1.2m and no more than 2.5m to the upper edge of the display characters when measured from the ground and the vehicle in its normal condition for travel.

3.8.7 The sign should be supported by brackets attached to either end of the sign.

3.8.8 Power feed to the controller should be 24 D.C supplied on 16AWG (1.5mm^2), 2 core cable. Communication to the controller should be supplied on 20AWG (0.5mm^2), 2 core cable and typically via a RS485 interface.

Rear sign

3.8.9 The rear sign should be mounted as close as possible to the rear window of the vehicle.

3.8.10 The physical space envelope required for installation should be a minimum of 340mm x 325m. There is no minimum height requirement for the mounting of the rear sign.

3.8.11 The sign should be supported by brackets attached to either end of the sign.

3.8.12 Power feed to the controller should be 24 D.C supplied on 16AWG (1.5mm^2), 2 core cable. Communication to the controller should be supplied on 20AWG (0.5mm^2), 2 core cable and typically via a RS485 interface.

Sign controller

3.8.13 The sign system controller should be located in a suitable location which is fully accessible by the driver, without compromising safety. Recommended areas for this area are a location in front of the driver in the dashboard or directly above the driver's head. The controller should not be located where there is a risk of water damage.

3.8.14 Power feed to the controller should be 24v DC supplied on 16AWG (1.5mm^2), 2 core cable. Communication to the controller should be supplied on 20AWG (0.5mm^2), 2 core cable.

3.8.15 The sign system controller should be capable of communicating via the required interface directly with the OBC/ticket machine used on the vehicle.

3.8.16 Cat 5 or RS232 cables and drawstrings should also be provided for connection to the controller.

3.9 Vehicle data feeds

Ignition signal

3.9.1 This is a signal to inform the system that there is a driver in the cab and the ignition has been switched on, and should be 24VDC and capable of supplying 2 amps. The connection should be fused at source, and identified as the ignition supply.

3.9.2 The ignition has a single cable to the cabinet.

Odometer signal

3.9.3 An odometer signal is often required to provide road speed data for dead reckoning etc. The odometer signal should be provided to the on-board cabinet.

3.9.4 The signal presented shall be a square wave pulse train, between 24VDC and 0VDC. The speed shall be indicated by the frequency of the pulses, configurable between 4 and 40 pulses per meter travelled.

3.9.5 A signal splitter should be provided, in order to supply three separate pieces of equipment with odometer information without loss of quality.

Door signal

3.9.6 A signal is used to indicate when any of the passenger doors are open. The signal has to be negative when any (0VDC) door is open and has to go off when the door is closed (24VDC).

3.9.7 Normally a separate signal from each door is required. However if two (or more) sets of doors are supposed to be opened and closed at the same time, only one signal is required for these two doors is needed.

3.9.8 A single cable per door signal shall be provided at the on-board cabinet.

Cabin lamps and bells

3.9.9 Lamps and bells may be mounted in the cabin as part of the passenger information system. These should offer the option of being controlled via the terminal block.

Accelerometers and turn rate sensors

3.9.10 Sometimes additional sensors will be required – for example vehicle linear or rotational accelerometers or turn rate sensors. Unless these are agreed in advance no special provision is required, but the general approach should be similar to the odometer (ie a pulse feed).

3.9.11 A specific mounting plate should be provided, and should be placed either on the horizontal or vertical plane – perpendicular to vehicle travel.

4 Provision for networked systems

4.1 Introduction

4.1.1 It is anticipated that a number of on-bus systems will, in future, be networked in a way (and using technology) similar to how office systems are connected: over an Ethernet network, using internet protocol (IP) communications. There are ruggedised systems suitable for an industrial environment and these should be fully suited to the environmental requirements of a bus.

4.1.2 Unlike the devices in section 3, this does not require direct wired connections between each unit and the on board computer. Instead, it implies a network access point at each relevant location. The wiring of the on-bus network (and whether, for example, it uses hub, switch or hybrid architecture) is wholly within the control of the bus builder.

4.1.3 All of the systems in this section need an Ethernet connection to the bus data network. In addition most will require:

- An earth;
- 24VDC power.

4.2 Network configuration and management

4.2.1 The on-board computer should expect to act as the network manager. The supplier should state whether IP addresses are managed statically or dynamically, and should maintain an easily accessible address table of connected devices.

4.2.2 Cables must not cut across sharp corners or be cable tied internally as they may require to be used as a pull through at a later date. They should be clamped at the termination in a way that allows for simple unfastening.

4.3 Electronic Ticket Machine

4.3.1 While future ETMs may use the on board data network, current ETMs largely use older wiring systems. The standard build should therefore allow a RS485 connection to the on-board computer as well as a data connection.

4.3.2 It is recommended to have a 30cm loop projecting beyond the ETM mounting point, to allow for future reconfiguration.

4.4 Driver display

4.4.1 Driver display units are covered by the general rule that the operator's cab committee will have an input into location and design. These specifications are therefore starter suggestions only.

4.4.2 Drivers are likely to be monitoring the display on a regular basis, even if it is only active when the bus is stationary. Therefore the display should be within an easy range of both head and eye movements, to minimize distraction from driving and minimize strain on the driver's neck and shoulders. There must be no obstruction, such as the steering wheel, preventing the display being easily seen by drivers of different builds.

4.4.3 The target size for the secondary (non-ETM) display device is 125mm high by 240mm wide by 50mm deep.

4.5 On-bus next-stop sign

4.5.1 Signs should normally be mounted as follows:

- For single deckers, on the ceiling above the central gangway, or behind the driver's cab.
- For double deckers, on the lower deck behind the driver's cab and on the upper deck mounted in the front of the bus.
- For articulated buses, on the ceiling in the middle at the front of each articulated section.

4.5.2 Passenger information systems come in a variety of styles. The target size for LED displays is 875mm wide by 170mm high by 100mm deep; panels should provide for ready mounting of displays this size.

4.5.3 Some operators are now beginning to use full-screen flat panel displays (eg TFT). No standard size or mounting position has been agreed for these yet.

4.6 Vehicle diagnostic systems

4.6.1 If vehicle diagnostic information is required, a link should be provided to J1939 CANbus, if available. Alternatively, a CAT-5 network port connected to the on-board computer should be placed in the driver's cab.

4.7 CCTV

Cameras

4.7.1.1 The standard camera used by CCTV integrators is the mini armoured dome, which will require a 60mm diameter hole. These cameras are used both internally and externally. Normally, similar cameras are used externally and are mounted in the same fashion.

4.7.1.2 External cameras can often be adjusted to different angles with the use of a 'wedge', which sits between the housing and the vehicle so the camera is then at an angle that allows an appropriate view along the side of the bus. Where a 'wedge' is used a 1.5" self drilling screw is used for mounting.

4.7.1.3 Also, depending on the view required, the camera lens may be 2.5mm (wide angle) or 3.6mm. The 2.5mm lens is often used for acquiring an image of the road from the front of the bus.

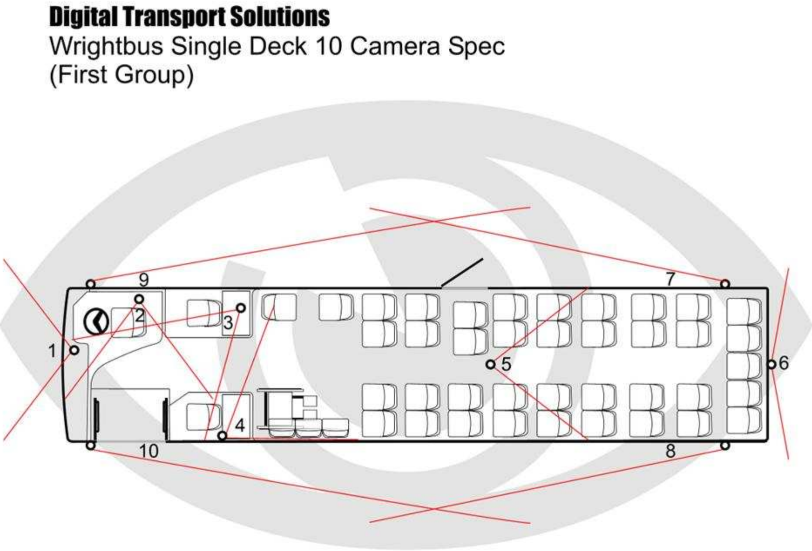
Camera positioning

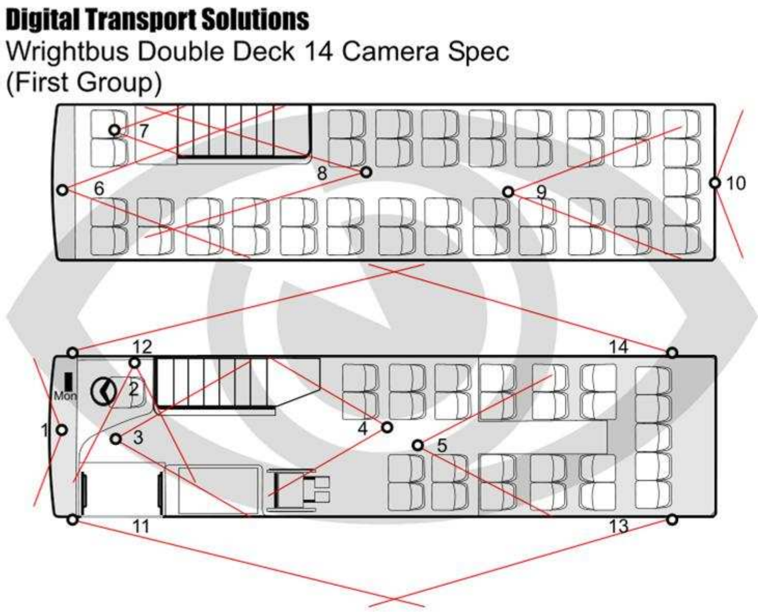
4.7.2 Generally speaking, on-bus CCTV systems will have approximately the following number of cameras:

- Single deck: 10 cameras (4 flank, 1 front (road), 1 back (road), 4 internal);
- Double deck: 14 cameras (as above, inc. 6 internal);
- Articulated: 16 cameras (as above, inc 8 internal)

4.7.3 The two diagrams below show possible positioning of CCTV camera locations (and angles) for single deck and double deck buses (note: watermarks and annotation will be removed for final document).

4.7.4 Note: A third diagram is being developed for camera positions on an articulated bus.





Digital Video Recorder location and size

4.7.5 The CCTV DVR unit should be housed in a dedicated locker space, or can be placed alongside the on-board computer in the cabinet. Easy of access and optimum air flow is crucial in both cases. DVR size can range between 400mm(L)x300mm(W)x120mm(H) and 680mmx380mmx150mm (all figures take into account airflow around the unit for heat dispersion. For key cabinet dimensions, please consider section 2.5.

Power requirements

4.7.1.1 15” CCTV monitors (if specified) tend to be particularly power hungry, around 3amps. Otherwise, the DVR will draw 1.2 amps, the cameras 0.1 amps each and the driver display 0.75 amps – a total of 4-5 amps for an average double-decker bus. This is in addition to the other on-board equipment.

4.7.1.2 Power supply should be as outlined in section 2.6.

Driver’s monitor

4.7.1.3 Xx

Cabling

4.7.1.4 CCTV systems generally use stranded four core cable to connect to the DVR unit. However, many CCTV integrators may specify their own specific cabling.

4.8 Passenger counting mechanisms

4.8.1 There are a variety of electronic automatic passenger counting mechanisms available, which will normally use a form of sensor (IR for example) in the boarding area to count passengers boarding and leaving the bus. These sensors, which will be mounted by the doors, will need Cat 5 cabling connecting them to the on-board computer/AVL system, as well as a power supply.

4.8.2 Camera based systems are also available, and these will have a similar set-up to CCTV cameras, but will need to be connected to the on-board computer and/or a separate recording module. These cameras will be fitted in the passenger boarding and departure areas.

A Standard ‘wide area’ antennae specification

A.1 Introduction

A.1.1 The number of antennae required by the modern bus is now proving to be an issue for system suppliers and bus operators. Space is having to be found and this usually requires the removal of vehicle roof panels, which usually are difficult to replace.

A.1.2 This appendix describes a standard wide area antennae specification for ‘equipped-buses’. Whilst this standard is entirely optional, RTIG hopes that it will be adopted by bus manufacturers in order for easier, less complicated and non-impactful system installations.

A.1.3 The standard outlines four standard wide area antenna (in addition to the regular analogue radio antenna) that should be considered when specifying a new bus build. If the provision for affixing these attennae is taken into consideration at an eary stage, bus builders and system suppliers will save time and money.

A.1.4 The standard also considers two approaches to implementing the four antennae. Firstly, four separate antennae, and secondly, an ‘all-in-one’ approach.

A.2 Separate antennae

A.2.1

A.3 All-in-one antennae

A.3.1 Some manufacturers offer an all-in-one antenna solution that offers VHF, GSM/GPRS, UMTS/3 G, WLAN and GPS elements.

A.3.2 The foot print for such a unit is approximately 958 x 144 x 59mm but dimensions will differ according to manufacturer. 2 x 25mm mounting holes are required, with 858mm centres. The unit will be roof mounted and is designed to be impact resistant. A ground plane is required for the VHF element.

A.3.3 300-500mm LMR200 connectors for each element are required, terminated with FAKRA SMB male.