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LEZ -Technical Systems Guidance in Scotland

Guidance for Systems Design, Procurement, Installation and Operation

Contents

Document history and status

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1. Introduction and Purpose

This document is intended as a guide for local authorities when purchasing and operating Automatic Number Plate Recognition (ANPR) camera systems for Low Emission Zone (LEZ) enforcement in Scotland. It describes the key technical issues and requirements for the design and specification, procurement, installation, operation and maintenance of roadside camera and back-office systems in preparation for the introduction of LEZs in Scotland.

ANPR camera-based solutions have been used for many years across the UK to enforce traffic regulations for parking and bus lanes. Following the development of Clean Air Zones (CAZ) in England and the Low and Ultra Low Emission Zones (LEZ, ULEZ) in London, these technical solutions – along with matters of good practice – have been advanced to provide the additional functionality required to implement and operate these zones in a robust, secure and effective manner.

Particular focus is given in this document to the following areas:

- ANPR camera technology;
- Back-office systems technology and functionality;
- General capabilities and limitations of ANPR cameras and the ANPR Back-Office System;
- Key issues and requirements for data communications networks;
- Systems and processes for vehicle identification;
- Integration and interfacing, including:
    - with existing systems and services, e.g. Penalty Charge Notice (PCN) processing and PCN payment;
    - with local data services, e.g. local exemptions databases; and
    - with national data services, e.g. Driver and Vehicle Licencing Agency (DVLA) database, national exemptions database.
- Processes for handling vehicle exemptions at both local and national levels;
- Processes for identifying the compliance status of UK-registered vehicles;
- Processes for identifying the compliance status of non-UK vehicles; and
- Processing penalties for LEZ contraventions (UK and non-UK vehicles).

This document also identifies key issues for consideration in relation to:

- The design and specification of LEZ systems;
- Tendering and procurement for LEZ systems;
- Installation, testing and acceptance of LEZ systems; and
- LEZ systems operation and maintenance.

Explanations of the terms and abbreviations used throughout this document are given in Appendix A. Other publications which are referred to in this document are listed in Appendix B.

2. LEZ Systems Overview

The key elements for LEZ systems design, specification, procurement, installation and operation are summarised below. Each of these elements is described and explained in further detail within this document.

Design and specification:

- Roadside and mobile ANPR cameras (including illuminators and processors) for the capture of vehicle details
- Back-office data storage and processing
- Databases and data interfaces including:
    - Back-office vehicle passage data
    - Interface with national exemptions database
    - Interface with DVLA database
    - Interface with local exemptions database (if external to ANPR Back-Office System)
    - Interface with other potential users of ANPR data (e.g. police), if relevant
    - Interface with (Penalty Charge) Notice Processing System (NPS)
- Contravention review facilities
- PCN processing facilities
- Camera mounting and housing infrastructure and power
- Data communications networks from roadside to the ANPR Back-Office System and between all back-office systems (including DVLA and national exemptions database)

Tendering and procurement:

- ANPR cameras (including enforcement vehicle if applicable)
- Back-office data storage and processing systems
- Enforcement review and PCN processing
- Camera mounting and housing infrastructure
- Power supplies to camera equipment
- Data communications networks
- LEZ signage and associated civils works

Installation of LEZ systems, services and civils works:

- Programme of works
- Final system ('as-built') detailed design and specification
- On-street and back-office systems installation
- Software development and installation
- System-to-system interface development
- Definition and documentation of operational processes

Testing and Acceptance

- Initial Type Testing
- Factory Acceptance Testing (FAT)
- Unit Testing and System Testing
- System Integration Testing (SIT), including end-to-end tests
- Site Acceptance Testing (SAT), including camera 'ground-truthing'
- System Proving, including service resilience and failover
- System security testing, including penetration (pen) tests
- Ready for Service (RFS) Testing
- Commissioning and Handover

Operation

- Staff resource (LEZ operations, management and administration)
- Staff training and awareness

Maintenance and support

- Cameras, back-office systems, power supplies, communications networks and signage

3. Roadside Equipment

Overview

The application and use of 'approved devices' in the form of ANPR cameras is an essential requirement of a LEZ in order to produce a data record to establish that a vehicle was driven within the LEZ and to determine whether the vehicle meets the specified emissions standard as outlined in The Low Emission Zones (Emission Standards, Exemptions and Enforcement) (Scotland) Regulations 2021. If non-compliance with the Regulations is detected, then the registered keeper may be liable for a penalty charge.

Automatic Number Plate Recognition (ANPR) Basics

What is an ANPR System?

An ANPR system aims to extract a text file with the Vehicle Registration Mark (VRM) from the number plate of vehicles in the field of view of a camera. The main elements of the system comprise ANPR camera(s), illuminator, ANPR processor, communications and ANPR Back-Office System; further details of each of these elements are provided in Appendix C.

The ANPR system aims to produce a Vehicle Passage Record (VPR) for every vehicle passing through the field of view of the camera, albeit with instances – for various reasons – where successful data capture of every passing vehicle is not possible.

The VPR is packaged and either transmitted immediately via the communications network to the ANPR Back-Office System or stored at the roadside along with other generated VPRs which are transmitted subsequently as a 'batch' of data.

Contents of a VPR

The VPR should contain everything that will be required for enforcement, including include the following as a minimum:

- Unique record ID
- The interpreted VRM from the ANPR camera
- The ANPR confidence factor
- Date and time stamp from a traceable clock
- Site identifier (or capture location if a mobile system)
- Camera(s) identifier
- ANPR read (both front and rear plate if available)
- ANPR image (both front and rear plate if available)

- Any overview images and/or video clips to show context

Additional information that could be included:

- The nationality of the vehicle detected by the ANPR system or, if nationality cannot be determined, whether the VRM is a UK or non-UK recognised format (relevant for the enforcement of vehicles registered outside the UK)
- Data from any ANPR trigger detector if installed (see Appendix C for further details of ANPR triggers)
- A flag for any live alarms associated with the site (e.g. to detect attempts to damage, remove or tamper with camera equipment)
- Vehicle direction of travel

Use of a VPR for Enforcement

The VPR is the key item of information used to enforce a LEZ. If analysis of a vehicle's VRM identifies that the vehicle is either out of enforcement scope (i.e. vehicle type not within scope of LEZ, is subject to a grace period or is compliant with emission standards) or is on an exemptions list, then the VPR is usually deleted and a record retained of the VPR having been for a compliant or exempt vehicle. Conversely, if the VRM identifies that the vehicle is within enforcement scope (i.e. vehicle type is within scope of LEZ, is not subject to a grace period and does not comply with emission standards) and is not present on an exemptions list then the VPR forms the basis of an enforcement record.

The first stage of enforcement is usually to issue a Penalty Charge Notice (PCN) to the registered keeper of the vehicle. This will contain the meta-data from the VPR enforcement record (comprising VRM, date, time, location of the contravention and direction of travel). It may also contain one or more images of the contravention captured by the camera, including number plate ('plate patch') and vehicle overview images. Image capture is not a regulatory requirement but reduces the likelihood of requests from the registered keeper of the vehicle for further evidence that a contravention occurred.

Fixed, Mobile and Re-Deployable ANPR Systems

ANPR systems are usually located at fixed sites and monitored continuously during the LEZ operational hours (so the cameras simply don't move from their original location). However, at least two other possibilities exist:

Re-deployable systems are ANPR systems that can be moved around a number of pre-prepared sites in accordance with an enforcement strategy. This approach is generally more cost-effective than equipping all fixed sites, while still keeping an acceptable degree of enforcement in place. It is usually beneficial to have power provided at all sites capable of hosting the redeployed camera. For data communications it may be possible to use mobile data network services for this type of deployment.

Mobile systems typically entail vehicle-mounted ANPR systems. Schedule 6 of The Low Emission Zones (Scotland) Regulations 2021 allows for the use of mobile camera systems to be used for enforcement. These should be operational only inside a LEZ to detect a moving vehicle offence, e.g. a stationary or parked vehicle cannot be causing a LEZ offence. The mobile enforcement vehicle (MEV) may be either stationary, parked or moving while it is operating. The main value of a mobile enforcement system in a LEZ scheme is where it is not practicable or economical to monitor all roads within a LEZ and/or at the LEZ boundary in a way that adequately captures the traffic within the LEZ.

Mobile ANPR use the same technology as a fixed camera but there are often practical challenges in positioning a mobile vehicle in relation to other road traffic in order for the camera to operate as effectively as a fixed installation in terms of vehicle capture. When considering using mobile enforcement units, the likely performance level should be checked with the system provider.

Mobile ANPR may also influence the perception of road users as to their chances of being detected within the LEZ, thus potentially providing a more credible deterrence compared to a fixed ANPR system.

For mobile systems it is important to decide the types/positions of vehicles to be monitored and also what types/situations should not be monitored. Circumstances in which the gathering of vehicle records should be supressed include a parked vehicle or when the MEV has driven outside the LEZ. The latter can be managed through a "geofencing" function whereby vehicle capture is automatically activated or deactivated according to the location of the enforcement vehicle inside or outside a pre-defined geographic zone (in this case the LEZ). Suppression of the monitoring of parked vehicles is a more complex challenge that may not be achievable automatically by the mobile ANPR system. In such circumstances it may be necessary to limit the operation of the ANPR system to areas where there is limited opportunity for on-street parking. Alternatively operation could be limited to when the MEV itself is parked and thus only monitoring moving vehicles, or to allow vehicle capture when the MEV is moving but then require manual review of the data by an enforcement operator to determine whether a captured vehicle was parked or moving.

ANPR Compliance Strategy, Plate Capture and Proving Liability for a Penalty

LEZ legislation in Scotland is based on the principle of 'driving within a LEZ' where the LEZ is regarded as an 'area scheme'.

Enforcement Compliance Strategy

The local authority must decide upon and design a robust, defendable enforcement compliance strategy. For example, ANPR cameras may be required to cover all or some of the major routes into the LEZ along with the major cross-zone routes or be located at every LEZ entry point.

Consideration should be given to major trip-generators endpoints such as shopping centres, industrial parks, distribution warehouses, etc. It may be necessary to prioritise placing enforcement monitoring on such routes.

The LEZ boundary (and associated enforcement locations perhaps, but not always, at the entry points) may trigger diversion activity to avoid the enforcement locations. If this prevents non-compliant vehicles entering the LEZ, then the enforcement regime should be regarded as a success. However, if entry points are not enforced and fixed camera positions within the LEZ become known, drivers may then learn to take routes that avoid the cameras; this aspect should clearly be considered in the design of the enforcement compliance strategy.

Mobile systems working in tandem with fixed systems can introduce an element of 'random' enforcement that can help to discourage drivers from attempting to evade the cameras, especially if the mobile enforcement element is widely publicised.

Front and Rear Plate Capture

Front number plates of vehicles are typically less obscured, in better condition and stay cleaner than rear number plates and so, if only one plate is to be monitored, preference should be given to front plates. In particular, the rear plates of trucks are often placed under long vehicle body overhangs and can occasionally be broken and dirty. On some foreign semi-trailer trucks, the front and rear plates are different, the latter reflecting the identity of the trailer, not the tractor unit.

It is for the local authority operating each LEZ to determine its enforcement tactics in terms of camera placement – for example, whether it is the use of front plate capture only, rear plate capture only or both front and rear capture at the same time.

Where a LEZ scheme adopts monitoring of front plates only, then the angle of the camera must be carefully considered so as to ensure the capture of vehicles purposefully driven close to the vehicle in front (i.e. 'tailgating' with the intention of avoiding detection). All systems will have limits on the angle at which the camera will operate effectively, as the height of the characters in the image is reduced and the lettering increasingly 'skewed' as the angle gets steeper.

Using both front and rear plate-reading cameras offers several advantages:

- It makes it almost impossible for a driver to avoid the cameras capturing the VRM from one or other plate regardless of driving behaviour.
- The system is better able to detect misreads, as it is highly unlikely that the ANPR system will misread in exactly the same way on both front and rear plates.
- The system is less likely to miss vehicles altogether, especially in an internally triggered system (see Appendix C).
- The system has more opportunity to capture the VRM where one of the plates is either obscured, damaged or missing.
- Additional evidence is available in case of a challenge to the issue of a PCN.

- It is able to detect motorcycles, if needed. Motorcycles do not have front plates so if the LEZ scheme requires them to be identified then rear plate reading will be essential. It should however be recognised that ANPR performance in regard to motorcycles may be less than that for other vehicles in both detection rate and read accuracy for the same reasons as above relating to condition, etc. of rear plates.

The use of both front and rear reading camera will clearly increase the cost of the enforcement system through the need for additional cameras and additional or alternative equipment mounting infrastructure. This approach may also create more challenges around the placement of mounting infrastructure, particularly if the street furniture is already congested or equipment needs to be located in sensitive areas (e.g. heritage zones).

With front and rear reading, it is desirable that both plate reads and associated images are brought together into the same VPR. This can either be done by the cameras monitoring a common area of road or there may be software logic that can link the records when they are geographically separated. Some systems use a separate sensor to track the vehicles between sensors.

The requirement for capture of front plates versus that for both front and rear plates creates a balance between improved performance against the increased cost and complexity. For many camera locations, front reading alone is likely to be adequate (noting the above issue regarding capture of motorcycles). In front-reading only schemes there may be some key front plate capture locations that could be supplemented with rear plate capture, for example:

- where there is potential for frequent 'tailgating' or obscuration by large vehicles
- where there is queuing traffic
- where the camera angle is sub-optimal (e.g. due to site-based restrictions on mounting arrangements)
- at particularly high traffic volume sites

Lane Coverage and Overlaps

ANPR software needs to have a certain density of camera pixels on the plate to be able to read it accurately and this factor limits the lane width that any camera will be able to monitor. There is no intrinsic performance advantage between a lower pixel count camera monitoring a narrow stretch of road and a higher pixel count camera monitoring a wider section of road. For the narrow field of view (FoV) on a wider section of road the local authority will either require more cameras to provide full coverage or accept that there will be gaps in this coverage. However, with the continuous improvement of camera resolution and image quality it now generally requires fewer cameras to cover wider areas.

Rather than specifying a camera pixel count, or even a lane width coverage for a camera, specifying the width of road(s) to be monitored may be more productive in

order for suppliers to offer solutions that provide suitable capture and read accuracy rates.

If multiple cameras are used across a carriageway, for full kerb-to-kerb coverage there should be a minimum 0.5m (i.e. one plate-width) overlap between the field of view of adjacent cameras (see Appendix D). This may be relaxed a little if lane discipline at the site is good.

On trunk roads with a hard shoulder, it is usually advisable to extend camera coverage to vehicles using the hard shoulder. This is to deter evasion and also to cover the situation where the shoulder is used as a running lane.

On single carriageway roads, especially on roads with low traffic volume, consideration should be given to vehicles swerving to the wrong side of the road to evade the cameras, or to pass parked vehicles etc. If this could be a problem, additional cameras may be needed.

Proving Liability for a Penalty

In terms of the evidence required to prove liability for the penalty, the local authority only needs to send the registration mark of a vehicle (assigned under section 23 of the Vehicle Excise and Registration Act 1994) to the DVLA to enable the DVLA to provide a record of the vehicle's emissions standard. However, the local authority should also consider collecting the make and model of the vehicle to aid with vehicle identification. The local authority is also required to record the date, time and location of the contravention.

Roadside Infrastructure

Roadside infrastructure design will influence the outputs possible from the ANPR system as indicated in the sections below.

Site Location Considerations

Site location is a critical consideration for effective ANPR operation. The location – and the precise orientation and alignment of the camera at that location – is important not only to maximise the ability of the camera to accurately capture the VRM of each passing vehicle but also to ensure that the captured VRM (and thus the associated vehicle) was clearly and unambiguously within the LEZ at the point of capture.

ANPR systems work best when the following aspects are created:

- ANPR systems work best in free-flowing traffic, so try to avoid sites which have queuing traffic for a high percentage of the day
- Sites with poor lane discipline should be avoided where possible. This may mean keeping clear of junctions
- ANPR systems work best with the plate square on to the camera, so sites on steep bends, or monitoring turning traffic should be avoided where possible

- Site geometry should always be within the manufacturer's specification. This is especially in relation to the offset and dip angles
- Low sun can adversely affect ANPR capture. East – West facing sites are likely to be more effected that North – South facing sites. In most cases however there may be limited opportunity to mitigate this
- Location of existing power and communications infrastructure may influence site location

Fixed Mounting Infrastructure

Fixed sites and re-deployable sites will need some mounting infrastructure. The nature of this will be specific to the scheme and the area but could include either a roadside pole (which could be, for example, an existing lighting column), a roadside pole with cantilever over the road, a portal gantry or an existing overbridge.

In some cases, it may be possible to mount a camera on a building. However, this will require agreement with the building owner and must consider how power and communications connections are to be made, i.e. from within the premises or externally to the building.

A camera mounted on a roadside pole will capture a high proportion of vehicles in the nearest lane, however there will be some obscuration of vehicles in a second lane out, especially in queuing traffic and especially with a high proportion of trucks, and a very large loss of vehicles in a third or greater lane unless there is a cantilever over the road.

A portal gantry offers the possibility of a very good overhead camera angle across all lanes but may not be the cheapest or most visually attractive solution.

Utilising an existing overbridge is a solution that has been used extensively for journey time monitoring, however it has not been used extensively for full lane coverage with multiple cameras.

For many cities, utilising existing infrastructure such as lighting columns, traffic signals and signage is likely to be the most cost-effective solution. This will favour the 'all-in-one' type of ANPR system, where the ANPR and overview cameras, illuminators, ANPR processor and communications are all packaged into one housing.

Most ANPR camera systems require camera mounts that are adjustable in three axes – pan, tilt and boresight rotation (or 'roll'). This is because most ANPR systems require the number plate in the image to be close to parallel with the top and bottom of the image frame. This adjustment also allows for "fine-tuning" of the field of view following installation to allow for occasions where a vehicle may not be identified due to its location on the extremity of the view (e.g. partial plate in the field of view) or where there may be potential for misidentification of a VRM (e.g. text from roadside or shop-front signage in the field of view).

Power

For most fixed installations the ANPR system will require a mains power supply, although a renewable source such as solar power may be an alternative (following advice from the supplier).

Consideration could be given to utilising power supplies for other roadside infrastructure, including traffic signals, signage etc. Street lighting supplies may not be suitable if centrally switched and they also tend to be very 'spikey' supplies and can damage the equipment if not smoothed.

Communications

It will be necessary to send the VPRs from the roadside to the ANPR Back-Office System. As such, there will need to be a communications network for this to happen, such as:

- a fixed line communications service (wide area communications network or WAN)
- an existing authority communication facility
- mobile data communications

Creation of a data volumes model will help to understand the size of the files to be transferred and the volume of traffic. The size of the VPR will, to a degree, depend on the type and resolution of the camera system.

It is important to have an available bandwidth at least double the calculated peak requirement to allow the system to clear a backlog of VPRs in the event of a communications interruption.

If the bandwidth of the available communications network looks to be insufficient to transmit every VPR, consideration could be given to storing the VPRs at the roadside for a short time, and a text file sent to the ANPR Back-Office System. This can then be checked against an off-line local exemptions list and if the vehicle is found to be exempt the VPR can be deleted at the roadside. If this approach is considered, the timescale for processing as defined in the document 'Civil Traffic Enforcement, Certification of Approved Devices - Low Emission Zone Version' should still be adhered to.

Resilience and Disaster Recovery

Any roadside system is vulnerable to damage, either deliberate or accidental, to power failures, and to communications failure. There are a number of measures that can be taken to minimise the impact of these events:

- Basic measures against vandalism can include no exposed wiring, high security locks and no exposed hinges on cabinets. Some systems may offer also physical security measures.

- Roadside equipment should be continuously monitored by the ANPR Back-Office System. Normally the roadside system should periodically send in a 'heartbeat' message indicating good operation, as well as alarms for any unexpected events, including any unauthorised attempt to connect to the equipment.
- Measures against power failure can include an Uninterruptible Power Supply (UPS) to at least allow the system to continue operation during a minor power 'glitch' and to perform an orderly shutdown in the event of a longer outage. It should also allow the sending of an alarm to the central system. More comprehensive measures like a standby generator may be considered if there is likely to be a long term power outage.
- The most usual measure against a communications failure is to have storage capacity at the roadside to store VPRs until such time as the communications can be re-established. If the outage is likely to be long term, it may be possible for an operator to visit the site and download the data locally, although the process for this while maintaining evidential integrity should be set out in advance.
- There is always the possibility that a site may be damaged as a result of a road traffic accident. Mitigation actions can include:
    - Protection of infrastructure such as the use of safety fencing
    - Carry a stock of spare equipment and supporting infrastructure (poles, cabinets, cameras etc.)
    - Have an emergency re-deployable system that can be quickly deployed

There will also be a central in-station system, and standard IT resilience measures should be taken with this, including recovery time objective and recovery point objectives in line with the business needs.

It should also be noted that there are some measures on data security and resilience in the aforementioned document 'Civil Traffic Enforcement - Certification of Approved Devices - Low Emission Zone Version'.

Installing ANPR on Trunk Roads

A LEZ may encompass one or more roads on the trunk road network – managed by Transport Scotland – and as such it may be necessary to install and operate ANPR sites on these roads.

In this event, Transport Scotland has advised that, in the first instance, the local authority (as it is the local authority that creates a LEZ, not Transport Scotland) should contact Transport Scotland and discuss its requirements. This should include any signage or other additions or alterations that might be required to Transport Scotland infrastructure in order to implement the LEZ. Transport Scotland should be involved at the earliest opportunity to reduce the risk of delay.

ANPR Performance

It is important that any system is designed to be resilient, taking into consideration that ANPR is not 100% accurate at all times and that performance will vary with a number of factors.

Factors Affecting ANPR Performance

ANPR systems are not perfect and will occasionally misread plates and in some cases may miss plates altogether. There are a number of factors that will affect ANPR performance but testing ANPR systems for resilience against all of these factors is practically impossible. It is important therefore to understand these factors and establish with the chosen supplier what measures they have taken to minimise the adverse effects. The Home Office document 'Guidance on ANPR Performance Assessment and Optimisation' lists some of these factors:

- Site geometry – the location of the system will impact on the ability of the camera to collect the necessary data (as noted above).
- Traffic conditions – As noted above, the traffic conditions and flow will impact on the data collection process.
- Sunlight – bright sunlight is the enemy of ANPR systems, especially low sun in front of the camera. Infra-red (IR) cameras and illuminators with narrow band-pass filters minimise these effects, as does exposure control systems that monitor the plate exposure rather than a scene average.
- Shadows – very similar to sunlight above. A plate half in shadow is particularly challenging. The same design features as described above will help with this.
- Rain and fog – in general all but the most extreme rain and fog will not have a significant effect on ANPR performance, although infra-red systems are less affected than visible light. A shorter camera to target distance will help, with a distance of around 12 metres or less being preferable for a typical 6-8 metre installation height.
- Ice and snow – There are two main problems; in snow, a build-up of snow will often obscure number plates, which is an unavoidable reality of weather on a particular day (although it is worth noting that driving with an obscured number plate is illegal). The other problem arises from the use of salt on the roads during icy weather. Plates may become salt-encrusted, which severely degrades the retro-reflective return from the camera illuminator. This requires a lot more illuminator power to read. However, some vehicles will have cleaner plates than others and the higher power may then over-expose these cleaner plates. Modern Complementary Metal-Oxide Semiconductor (CMOS) camera systems are better able to cope with this than older Charge-Coupled Device (CCD) based systems. However, best practice is to expose the plate at different levels as it travels though the field of view. The face plates of the ANPR system may also get encrusted with salt which is sprayed up from the road. Regular cleaning may be needed to reduce this.

- Illegal number plates – Some vehicle owners fit illegal number plates to their vehicles which might involve the alteration of a font type, size, or the whole size of the plate being changed for cosmetic purposes. In general, ANPR systems cope well with most of these types but some changes will lead to incorrect reads. If such plates form a large percentage of traffic this may affect the overall read rate. Most suppliers will seek to have such plates excluded from any accuracy testing.

How to Specify ANPR Performance and Testing

There are two main measures of ANPR performance:

Capture Rate – the percentage of vehicles passing the camera FoV that creates a VPR.

Read Rate – of the captured VPRs, the percentage that are correctly interpreted by the ANPR system.

The police specify the following performance levels for their systems, as defined in the document 'National ANPR Standards for Policing and Law Enforcement':

System type	Capture Rate - % of all VRMs that are visible to the human eye	Read Rate - % of captured VRMs accurately read
Fixed and Re-deployable Systems	98%	95%
Mobile Systems (Vehicle Mounted)	98%	95%

Table 1 - Performance levels for police ANPR systems

These levels of performance are generally regarded as being high but achievable by the industry, although they are more demanding than would be required for example for journey time monitoring. These minimum performance levels should be specified for a LEZ system, but system suppliers should be encouraged to exceed these as far as possible to reduce effort and cost later on in the enforcement process. For example, the more effective and accurate the capture and read rates are then the less input (e.g. reviewing) is needed in the downstream process for checking and reviewing the VPR.

Some systems define a third measure of performance – lost vehicle rate. This is where a VPR is created for the vehicle but it cannot be identified from the images (even by eye). This should generally be less than 0.75% of VPRs.

Testing ANPR performance is known as "ground-truthing". This process involves capturing a video stream of the actual traffic at the same time as the capture of ANPR data for those vehicles. The video stream can be a feed from the ANPR cameras themselves or from separate video cameras. This video is then manually evaluated and compared to the captured ANPR data. Any missed vehicles or misinterpreted vehicles are noted. It is a time-consuming process, but it is the most

critical aspect of system performance and very important that the required performance is proven.

There is a very good description of the ground-truthing process produced by the Home Office in the document 'Guidance on ANPR Performance Assessment and Optimisation'. This process is recommended for local authorities. However, the following additional points should be noted:

- The guidance recommends a sample size of 250 vehicles. This sample size has been selected for practical and cost reasons, however for statistical significance a larger sample size would be required – probably around 500 vehicles (= 10 times the 1 in 50 accuracy, providing +/- 4% margin of error at 95% confidence level).

- Human evaluators are fallible. It is easy for the eye to be misled, especially if it is presented with a suggestion of a VRM. The best practice is to evaluate the correct read rate using 'blind entry'. This is special software that brings up the images in the VPR to an operator and, rather than presenting the ANPR read, instead it asks the operator to key in the VRM from the image. The software then compares this to the ANPR read and, if there is any discrepancy, asks the operator to decide whether the ANPR or the operator-keyed VRM is correct. This is obviously a slightly slower, but more accurate technique.

Any camera identified as performing below the required minimum capture or read rate would require further investigation and potential remedial work, such as realignment of the camera view or reconfiguration of camera image and other settings (e.g. aperture, focus).

The local authority will need to decide on the importance of accurate ANPR reads and therefore how rigorous the testing procedure should be. It is recommended that all PCNs are manually reviewed for correctness. However, too high a proportion of missed or incorrect plate reads will inevitably lead either to incorrect PCNs being issued or PCNs not being issued for non-compliant vehicles that travel in the LEZ, both of which could damage the reputation of the scheme.

It should be noted that the raw accuracy of the ANPR data from the ANPR system is unlikely to be by itself of sufficient accuracy for enforcement purposes and that some subsequent filtering and review will probably be necessary.

ANPR Vehicle Passage Records

The VPR will be the sole basis of evidence given in a PCN, which may be subject to appeal, and so will have to withstand challenge and very close scrutiny.

VPR Capture, Storage and Transmission

The VPR should be encrypted and authenticated at the roadside in accordance with the requirements of the document 'Civil Traffic Enforcement - Certification of Approved Devices - Low Emission Zone Version'. The transmission may be over what is referred to in the above document as a 'public' network but it should be

received at the ANPR Back-Office System by what the document refers to as an Evidence Retrieval and Control Unit (ERCU).

The basic VPR should be retained as an evidential record. Working copies can be made and used in further processing. A text file will be required to be extracted for transmission to the central system for emissions compliancy checking and matching to exemptions lists.

Downstream Processing of VPRs

In most LEZs a portion of the total vehicle fleet may not be subject to the restrictions of the LEZ. Nonetheless, as many vehicles as possible entering the LEZ or driving within it should be identified in accordance with the enforcement compliance strategy. This will allow determination of which are emissions compliant, which are not, and which are present on an exemptions list. This will inevitably produce high volumes of ANPR reads.

Even if the ANPR system fulfils an approximate 95% read rate, this means that up to 5% of all VPRs may have been read incorrectly. Some LEZ schemes may have daily ANPR read volumes in the hundreds of thousands, so a potential 5% error represents a considerable volume of erroneous VPRs. If these are not corrected, then this could lead to an incorrect PCN being issued. This correction process requires a commensurate level of operator resource to manually review the potentially erroneous records.

The situation is made more difficult by the fact that there is no 100% reliable indicator in a VPR to determine if it has been incorrectly read. The ANPR system will provide a confidence value of the read to identify how confident it is that the read is correct. Nonetheless some high confidence reads may still be incorrect and some low confidence reads may in fact be correct.

Thus, there is a need to ‘cleanse’ the data before it is issued to the central system for compliancy checking and cross-referencing with exemptions lists. The degree of data cleansing and number of the techniques required to minimise manual image review are to the choice of the local authority and may depend on the volume of VPRs and the perceived consequences of letting through erroneous VPRs. Details on the downstream processing of VPRs is outlined further in Appendix F.

Evidential Integrity

The VPR is usually the sole source of evidence for issuing a PCN. The cost of a PCN can escalate if the recipient does not respond in a timely manner – and for repeat contraventions – and PCNs may be challenged through the representations and appeals processes.

The local authority will be using enforcement powers provided through the Low Emission Zone (Emission Standards, Exemptions and Enforcement) (Scotland) Regulations 2021.

Certification of Approved Devices (CoAD)

The Low Emission Zones (Scotland) Regulations 2021 require that devices used in connection with the operation of a LEZ must be 'approved' for this purpose, which means that:

a) it meets the requirements specified in schedule 6 of these regulations; and

b) it is of a type that is certified by Scottish Ministers as meeting the schedule 6 requirements.

It is important to note that, although final certification of the system is by Scottish Ministers, this will rely to a large extent upon the local authority for each LEZ to have received formal certification for their system under a civil version of the Home Office Type Approval (HOTA) process, as required for the enforcement of criminal law such as speed cameras. This process is referred to as 'Civil Enforcement – Certification of Approved Devices' or CoAD for short.

This type of certification is commonly used for bus lane and parking enforcement systems whereby a technical assessment of the system is carried out by the Vehicle Certification Agency (VCA) to determine whether it meets the requirements for certification. If so, then a certificate is issued by the VCA for that system.

The VCA publishes a CoAD standard to enable enforcement authorities to design, implement and document their system in such a way as to facilitate certification. A CoAD standard is to be specifically developed for LEZs in Scotland in due course.

It is required that any LEZ enforcement system is compliant with the appropriate parts of the CoAD standard. LEZ enforcement systems will generally be classed as an 'unattended system' meaning that data is acquired by ANPR cameras in the absence of any direct action by an operator. It should be noted that some parts of the standard are advisory and some parts mandatory. Clearly it is only necessary to comply with the mandatory parts, although it is strongly advised to carefully consider the advisory parts as well. Requirements for mobile systems should also be noted where the use of these is envisaged.

The LEZ system supplier must create a Technical Construction File (TCF) describing how the system and processes are compliant with the standard. This file must be kept updated during the life of the system and there is a change process which must be adhered to where the supplier proposes any change to the system.

One of the most important aspects of compliance to the CoAD standard is ensuring that the images produced by the ANPR system are of sufficient evidential standard. The images are the most visible part of the evidence produced and it is essential that quality is upheld in order to prevent either the adjudication service – who will oversee the appeals process for LEZs – or the public regarding the quality as insufficient.

Role of the Vehicle Certification Agency

The VCA will evaluate the TCFs (for LEZ-approved devices) submitted by suppliers and make recommendations to Scottish Ministers on whether they should approve the system.

It should be emphasised that, by comparison to HOTA, the CoAD is a much more interactive and cooperative process and early and continuing discussions between the supplier and the VCA regarding the TCF on the design is encouraged to ensure that final approval is not problematical.

4. Back Office Hardware and Software

Data Collection and Management

There are several elements to the storage and processing of data transmitted from the roadside equipment to the ANPR Back-Office System. This includes the initial processing and filtering of data and the exchange of that data with other systems to determine vehicle type and emission status, from which further action can then be taken according to the results of those queries.

The key requirements for data collection for LEZ operation are:

- collection of ANPR data for all vehicles passing cameras in order for the ANPR Back-Office System to determine emission status of every vehicle
- database of local exemptions – what local exemptions are to be adopted (including time-limited exemptions known as grace periods) and what services are in place to enable a vehicle user to apply for an exemption
- There could be some form of a daily list to ensure vehicles are only issued one PCN per day and other detections are discarded. There will be many vehicles which cross boundaries multiple times per day and need to be dealt with.
- database of national exemptions – need to determine how this is established and managed and by whom
- interface to DVLA database ('vehicle description service') to check vehicle Euro emission status of non-exempt vehicles
- Notice processing database (including PCN status, appeals and payments) to determine PCN value and relevant surcharges
- non-UK registered vehicles – what process to adopt and what services are required to determine vehicle compliance and to issue Penalty Charge Notices (PCNs) to non-compliant vehicles

Processing of Data

The vehicle detection element of the LEZ is usually carried out at the roadside using image processing software, from which a VRM and associated data is produced along with still or moving images of the vehicle and of the VRM. Alternatively, this image processing can occur within the ANPR Back-Office System if a 'live' video feed from each camera is transmitted to it. However, this approach is less common as it requires an extensive high-capacity communications network to provide such feeds.

In either case, the resulting data for that capture event is packaged into a VPR containing details of the VRM and the time of capture along with a percentage estimate of the accuracy with which the image processing software has correctly

identified the VRM. This is accompanied by a still "close-up" image of the VRM and one or more still images (or, in some cases, a video image) of the wider scene showing the vehicle within the LEZ. This "context" view also assists with manual identification of vehicle type wherever such confirmation is needed, e.g. in the contravention review stage prior to production of a PCN.

The VPR, if produced at the roadside, is then transmitted to the ANPR Back-Office System and may then undergo a process of verification (and possibly correction) as described in Appendix F of this guidance document.

Once any automatic or manual data verification or correction process is completed then further checking of the VPR for exemption/compliance can be undertaken, as described below.

Step 1 - Checking Local Exemptions

For all captured VRM records, the initial stage for compliance checking is usually to cross-reference against any local exemptions data held by the local authority to determine if the vehicle is exempted from prohibitions on non-compliant vehicles accessing the LEZ. This dataset may also include vehicles eligible for entry during a time-limited "grace period". If a captured vehicle is identified in the local exemptions database, then no further action is required and the data record can be deleted.

Step 2 - Checking National Exemptions

If the captured VRM is not present in the local exemptions database then the next stage is to cross-reference against any national exemptions (e.g. historical and army, navy and air force vehicles), the database for which is expected to be managed and maintained by Scottish Ministers. An interface between the ANPR Back-Office System and this database is required to determine if the VRM is exempt. Again, if a captured VRM is identified in this database then the captured VRM record would be deleted.

Step 3 - Checking Vehicle Compliance (UK-Registered Vehicles)

Once it is established that a captured VRM is neither in the local nor national exemptions databases then the next step would be to determine if the vehicle is compliant, primarily whether it meets or exceeds the Euro emissions standards as specified in The Low Emission Zones (Emission Standards, Exemptions and Enforcement) (Scotland) Regulations 2021. This requires access to DVLA data, with a suitable interface from the ANPR Back-Office System to the DVLA database.

The interface between the ANPR Back-Office System of each local authority and the DVLA database may be direct or it may involve an intermediate central services provider. In the former case, each local authority would check the vehicle emission status directly with the DVLA and each would require a separate agreement with the DVLA to do so. In the latter option, each local authority would interface with the central services provider. Service agreements would then be required between the central services provider and the DVLA as well as between the central services provider and each local authority.

Although DVLA data is generally considered to be accurate, it is understood that some anomalies in the data do exist, including the absence of emissions standards data for some vehicle records. It would therefore be necessary for a ANPR Back-Office System to provide a means by which any such anomalies are identified and logged for feedback to DVLA so that omissions or errors could be rectified by DVLA.

Compliance Status of Non-UK Vehicles

All commercial ANPR camera enforcement systems are capable of capturing and identifying the VRMs of foreign (i.e. non-UK registered) vehicles and most systems are also able to determine the country of origin from the format of the VRM (which is usually included in the VRM capture record). However, there are no DVLA records of foreign vehicles other than those that have been in the UK for more than six months and are thus required to register with the DVLA.

For all other foreign vehicles for which no UK records exist, the local authority may decide to require all foreign-registered vehicles to register compliance prior to their journey using the same facility used for registering local exemptions.

Alternatively, the local authority may elect to employ a third-party service to conduct further investigations of the compliance status of non-UK vehicles. There are several such organisations with access to the databases of European countries who operate on behalf of UK local authorities to determine compliance with traffic regulations. However, it should be noted that, while these organisations do have access to some European databases, there are many countries in Europe where this data is not available to them or, if it is, then it contains little or no accurate data on Euro emissions standards.

If such third-party services are used, then an interface would be required between the relevant provider's system and the ANPR Back-Office System. The ANPR Back-Office System would then identify any VRM capture record of a foreign vehicle for which there is no record in the DVLA database and issue that record to the central services provider for further processing.

The central services provider commonly offers a service for the generation of PCNs in the language and format of the relevant country and for the handling of any subsequent action by the recipient, e.g. payment, escalation of charges for non-payment and appeals from the PCN recipient. Whether or not such services are to be included are subject to discussion between an individual local authority and the central services provider.

Determination of a Contravention

For a UK-registered vehicle, once a potential contravention is identified by the ANPR Back-Office System then it is standard practice for manual review of the captured VRM record to confirm that the contravention has taken place. The ANPR Back-Office System includes a "contravention review suite" to display the VRM record alongside the context images (or video, if used). This allows a LEZ operator to:

- compare the image of the VRM with the resulting VRM data

- confirm that the image processing software correctly identified the VRM
- confirm that the DVLA emissions data for that vehicle shows that it is non-compliant, i.e. it does not meet the vehicle emissions standards for entry to the LEZ

If the vehicle is found to be non-compliant then the case can proceed to PCN production stage.

It is important to note that, given that the volume of vehicles captured by a LEZ system would be significantly greater than that for a standard (e.g. bus lane) enforcement system, it is likely that the volume of manual reviews of potential contraventions would also be significantly greater, with a corresponding requirement for staff resource to undertake this.

PCN Production

The process for production and issue of PCNs for a LEZ is identical to that for well-established activities such as bus lane enforcement and uses the same back-office system, known as the Notice Processing System (NPS). The ANPR Back-Office System would require an interface to the NPS to enable transfer of the details of the contravention following processing in the contravention review suite, as described above.

The NPS also includes an interface to the DVLA database to obtain the name and address of the registered owner of the vehicle to which to PCN would be issued. From this point on, the process for issue of PCNs as well as payment of the charge(s) and any representations made against payment is as for standard enforcement practice. It is therefore not considered necessary to describe this in further detail within this document.

Handling of Penalty Charge Surcharges for Multiple Contraventions

One key feature of LEZs in Scotland is the inclusion of penalty charge surcharges for any contravention made less than 90 days after a previous contravention. This would require a change in the functionality of the NPS to retain a record of contravention for at least 90 days so that any contravention for the same vehicle that occurs less than 90 days from this first contravention can be identified as a second contravention and the appropriate (first) surcharge applied.

Furthermore, the record of the first contravention would need to be retained beyond this 90-day period if a third contravention for that vehicle occurred less than 90 days from the second contravention. This requirement would then repeat up to the point where a sixth contravention is identified, whereby the first contravention could be removed from the records given that, for the purposes of a surcharge, a sixth contravention is considered the same as a fifth contravention.

Therefore, a “worst case” scenario where a contravention for the same vehicle was identified exactly every 89 days repeatedly would require the retention of five contravention records spanning a period of 356 days. At the opposite end of this scale, any contravention record that is 90 days old (or older) can be deleted if there are no further contravention record(s) for that same vehicle in the 90 days since the

date of that record and if the correct penalty charge has been paid and there is no challenge (representation or appeal) in progress.

A clear process for de-escalation – and potential refund(s) to charge(s) paid – also needs to be established in the event of any successful appeals that result in a reduction in the surcharge for any subsequent contravention(s).

5. Data Communications

The data communications network is a critical aspect of the LEZ service, primarily for the transmission of data from the roadside cameras to the ANPR Back-Office System but also between the ANPR Back-Office System and other external systems including the DVLA database (or intermediate service where relevant). It is essential to understand the likely volumes of data at all stages of data transmission to ensure that the communications network has sufficient capacity to deliver this data. It should be noted that data volumes for a ANPR Back-Office System are likely to be significantly higher than standard (e.g. bus lane) enforcement systems at all stages of the process. The design of the communications network will need to take this into account.

Communications Networks Required for LEZ

- Between roadside equipment and the ANPR Back-Office System
- Between the ANPR Back-Office System and the NPS
- Between the ANPR Back-Office System and other external systems, e.g. DVLA, Transport Scotland (if providing the national exemptions database)

Determining Options for Data Communications

For this reason, the type and capacity of the communications network between the camera locations and the ANPR Back-Office System should be carefully considered. The type of connectivity can be determined on a location-by-location basis to determine the most effective solution for the location. For example, at some locations the use of a mobile network service may be appropriate where data volumes are expected to be moderate or low, such as on minor residential roads. On busy major routes where data volumes are likely to be consistently high, mobile or other wireless networks may not be sufficient or may be prohibitively costly to operate, in which case optical fibre or high-capacity standard landline networks may be more suitable.

In selecting an appropriate type of communications service, consideration also needs to be given to the availability of existing communications networks at or near to the camera locations. Installation of new ducting and cabling to provide communications connectivity is often costly, time consuming and disruptive and usually particularly challenging in urban environments. Available footway space for such installations may be limited and/or local sensitivities may be predominant, such as if there is a focus on area conservation (e.g. if the area is of historic, architectural or environmental interest). In such cases, the use of a mobile network may be more appropriate as there would be no physical work required to establish a communications service.

Communications Network Resilience

Another consideration for a LEZ communications network is resilience to ensure that data communications are maintained in the event of any service interruption. This

commonly involves installation of a secondary communications network – along with associated connection devices (e.g. routers, switches) – so that if any interruption occurs in the primary network then then this 'backup' network would automatically take over until such time as the primary network is reinstated. This could, for example, include a combination of an optical fibre network and high-speed business broadband connections for the primary network between each camera and the ANPR Back-Office System and installing mobile network connections at each camera or other variations depending on existing arrangements within the local authority.

6. Specification Considerations

The Low Emission Zone Regulations (Scotland) 2021 (Part 4) determines that only Approved Devices shall be used for the detection and identification of vehicles entering or driving within a LEZ and that this equipment will have been certified by the Scottish Ministers. Certification will be undertaken by the VCA on behalf of the Scottish Ministers based upon technical guidance provided to the local authorities in the document 'Civil Traffic Enforcement - Certification of Approved Devices - Low Emission Zone Version'.

Further to this, it will be necessary for tendering purposes to develop a detailed technical and operational requirements specification for the ANPR cameras and the ANPR Back-Office System. The core elements of this specification should align closely with the technical guidance for Approved Devices described above. However, the specification should also describe the required functionality, performance and connections with other systems as well as identifying requirements for implementation, testing, training, documentation and any other aspects of the proposed system and its operation that the local authority would require from a systems supplier.

A typical structure for a LEZ technical and operational requirements specification may include the following:

- Introduction
    - Overview of Proposed LEZ System
    - Definitions and Terms
    - Roles, Responsibilities and Scope of Works
        - Local Authority
        - Contractor
        - Third Parties (e.g. DVLA)
- General Requirements
    - Applicable Standards and Specifications
    - Hardware
    - Software and Firmware
    - Electrical Requirements
    - Reliability and Maintainability
    - General Legislative Requirements, (e.g. Equality Act 2010)
- Physical and Functional Requirements
    - Site Equipment

  - Back Office System
  - Data Flow Process
  - Site Equipment (Camera) Data Capture and Processing
  - LEZ Central System Data Processing
  - Contravention Review
  - PCN Processing and Representations
- Systems Interfaces
  - Interfaces to any existing Local Authority systems (e.g. NPS, local exemptions database)
  - Interfaces to External Systems
    - DVLA
    - Scottish Ministers (for national exemptions database)
    - Non-UK vehicle enquiry system (if used)
    - Others (if relevant e.g. police, traffic network management system)
- Installation Requirements
  - Site Equipment Installation
  - Back Office Installation
  - Systems Interfaces
- Testing and Commissioning
  - Factory Acceptance Testing (FAT)
  - Unit Testing and System Testing
  - System Integration Testing (SIT)
  - Site Acceptance Testing (SAT)
  - System Proving
  - System security testing (including penetration (pen) tests)
  - Ready for Service (RFS) Testing
- Training
  - Initial Training

    - Ongoing Training
- Documentation
    - Document Submission Requirements
    - Quality Plan
    - Health and Safety Plan
    - Final System Specification
    - Installation Plan
    - Test Plans/Test Specification
        - for each stage of testing described above
    - Test Results/Test Records
        - again, for each stage of testing described above
    - Test Certificates
        - for all of the above test stages to register test completion
    - Training Plan/Schedule
    - Commissioning Reports
    - Operations Manual
    - Maintenance and Service Manual
    - Hardware Manual
    - Master Record Index
    - Master Document Record
    - Electrical Certification
- Maintenance and Support
    - Maintenance Priorities and Response Times
    - First-Line Maintenance
    - Support Service
    - Spares
    - Hardware and Software
        - Revisions, Upgrades and Replacements
        - Hardware and Software Licensing

    - Preventative Maintenance
    - Maintenance Performance Monitoring and Reporting
        - Fault Management System
- Programme of Works
    - Contract Progress Meetings
    - Contract Performance Review (including KPIs where defined)
- Additional Information (as required)
    - Technical Terms and Abbreviations
    - LEZ Boundary and Indicative Camera Locations
    - LEZ System Proposed Data Flow Process

7. Procurement and Contractual Considerations

There are various well-established routes to procurement for a LEZ and each authority will have its own preferred approach. It is therefore not intended that this guidance details all such options and associated issues, nor to make any specific recommendations for tendering and procurement but is instead limited to describing general common factors and considerations for an authority when deciding upon a procurement route and method.

Determining System Technical and Operational Requirements

One of the key requirements for successful tendering and procurement is to develop a clear set of requirements for the LEZ System as described in Section 6. This should include requirements for supply and installation of the following elements of the LEZ System:

- ANPR cameras (including mobile enforcement vehicle where relevant)
- Roadside equipment mounting and housing infrastructure (e.g. posts, cabinets)
- Power supplies to camera equipment (and where relevant to communications services)
- Data communications networks to connect the ANPR Back-Office System to:
    - Roadside detection equipment, i.e. ANPR cameras
    - DVLA database (or intermediate service if relevant)
    - National exemptions database
    - Local exemptions database (including provision of time-limited exemptions for grace periods)
    - Notice Processing System
    - Non-UK vehicle enquiry system (if using)
    - Other third-party systems (e.g. police, traffic management)
- ANPR Back-Office System, including facilities for:
    - Interfacing to and data exchange with all of the above services
    - Data processing and data storage
    - Contravention review
    - Data management (e.g. deletion of data, recording of errors or omissions in DVLA data)

  - Administration and configuration (e.g. interfaces, backups, connections, system logs, operator access, reports)

- Notice Processing System, including:
  - Interface to Back-Office System for receipt of LEZ contravention data
  - Data processing and data storage, including storage of historical data to determine the application of surcharges for repeat contraventions
  - PCN review
  - PCN production
  - Interface to DVLA data to obtain details of registered vehicle keeper
  - Interface to PCN Payment Service to identify if/when PCN payments are made
  - Administration and configuration (e.g. interfaces, backups, connections, system logs, operator access, reports)
  - Facilities to support the logging and handling of representations/appeals
- PCN payment service, including interface to Notice Processing System
- LEZ signage and associated civils works

It is anticipated, however, that local authorities would undertake some form of competitive tendering for these elements or, for those authorities where ANPR camera-based enforcement systems are already operational, would enter into dialogue with those suppliers to determine options to extend those systems to encompass LEZ operations. In any case, it is still considered important to develop beforehand a clear set of technical and functional requirements for each of the system elements being procured. These may be modified during dialogue with suppliers or with tenderers during the tender process but would at least form the basis for the proposed solution and the frame of reference by which the delivery of the technical solution could be measured.

Appendix D includes further details of the procurement specification minimum requirements that an enforcement a local authority may wish to consider based on the guidance outlined in this document.

8. Installation

Installation of a LEZ system requires the following aspects to be agreed and defined with each of the systems suppliers:

- Integrated delivery programme, coordinating all elements of the work
- Final system detailed design and specification
- Health and safety plans
- Test plans, processes and records – for individual elements of the system and for integrated elements, including wherever data is exchanged between systems
- Technical, operational and maintenance documentation
- Asset records for roadside and back-office systems hardware and software

On-Street and Back-Office Installation

This primarily comprises the installation of all cameras along with suitable mounting and housing infrastructure for the camera equipment, which may utilise existing infrastructure such as street lighting columns or traffic signal posts or may require new mounting infrastructure if existing infrastructure cannot be used, e.g. if street lighting columns are not designed to accommodate the loading from camera equipment.

Provision of communications connections and mains power supplies is a key element of installation, indeed possibly the most critical in terms of planning and preparation given that these are likely to comprise the majority of on-street works through ducting, cabling and connection. Power and communications services often require significantly longer timescales for installation than most other elements of enforcement systems so this needs to be considered when determining LEZ delivery timescales and for subsequent ordering of power and communications services.

The extent to which back-office systems hardware and software needs to be installed within the local authority facility would depend largely upon the proposed technical solution. As for most CAZs, it is likely that most, if not all, proposed LEZ solutions would involve the ANPR Back-Office System being established as a hosted service on a commercial server platform with the local authority having remote access from workstations at the local authority facility. In such circumstances 'local' hardware and software installation would most likely be minimal and largely limited to installation and configuration of the LEZ workstations along with any required client software.

It is likely, however, that input would be required from the local authority IT services provider to ensure that all communications networks are in place and operational and have been tested, including resilience testing to ensure that backup networks operate in the event of failure of primary networks. These networks may also require

the IT services provider to specify, procure and install new communications hardware such as routers and switches.

Software Development and Installation

It is anticipated that proposals for the use of ANPR cameras and for back-office systems hardware and software for LEZ operation would be based to a large extent upon existing systems for ANPR camera-based enforcement – including bus lane enforcement and, more recently, CAZs – as the technology requirements and processes involved for data capture, processing and analysis are very similar. However, there are a few key differences between a LEZ, a CAZ and an ANPR camera-based enforcement system that require consideration in terms of software development for LEZs. Most notably, LEZs in Scotland are not charging schemes so there is no requirement for a service to enable payment for driving within a LEZ. There is, however, a requirement for a service to enable payment of a penalty charge where a PCN has been issued for a contravention of the LEZ regulations.

A typical ANPR bus lane enforcement system is based on 'exception reporting' through identifying and processing the details of any passing vehicle that does not appear in a pre-defined VRM exemptions list and then considering all these records as potential contraventions for review. Conversely, a LEZ requires capture and identification of the VRMs of all passing vehicles – or at least as many as practical – to determine compliance through analysis by the ANPR Back-Office System (after local exemptions list filtering at the roadside where this is established). Only those then determined as non-compliant are taken forward for review as potential contraventions. Therefore, a different approach is needed for the processing of captured VRM data than for existing ANPR camera-based enforcement. However, it should be noted that the system functionality required to do this for LEZs has largely been developed and implemented by all of the major ANPR camera enforcement systems suppliers for CAZs over the past few years. One key exception to this is for penalty surcharges, which do not apply to CAZs and so the NPSs for these systems do not currently provide this functionality.

The key requirements for application development would be the interfaces between the ANPR Back-Office System and the other systems with which data is to be exchanged. However, again, much of this work has already been undertaken with development of CAZs so this should not constitute a significant development risk.

9. Testing and Acceptance

Testing of any LEZ system should primarily demonstrate compliance with requirements set out by the local authority as described in this document. Test results should be recorded in a compliance traceability matrix, listing every requirement and indicating the test phase it will be proven in.

It is vital to ensure that a thorough testing process is planned and agreed with all involved parties. This not only includes the suppliers of the Back-Office System but also those with which data will be exchanged. In particular, this process should closely involve DVLA or the intermediate central services provider for DVLA data if such a provider is used. It should also require close cooperation between the ANPR Back-Office System supplier and that of the NPS to ensure that data exchange mechanisms as well as data content and format are fully understood, agreed and tested.

Tests should be developed to replicate the 'live' operation of the system under varying conditions. This should include stress testing (e.g. with high volumes of VRM captures presented to ANPR Back-Office System and submitted to DVLA or intermediate service for compliance checking) to confirm that the system continues to operate effectively under conditions of high data load and intense data processing.

System resilience testing should also be employed to confirm that backup networks and servers enable continuous operation of the LEZ System in the event of any interruption to the primary networks and/or servers.

It is also common practice with such systems to undertake penetration (pen) testing prior to commissioning of the system. This would comprise an authorised simulated cyberattack on the LEZ System to assess if it is sufficiently secure to withstand similar attacks in the future and to identify any security vulnerabilities that should be addressed.

One critical aspect of Site Acceptance Testing is 'ground-truthing' of the ANPR cameras. A description of this ground-truthing process is provided in Section 3.

Appendix I outlines further details relating to testing and acceptance.

10. Operations and Maintenance

The introduction of a LEZ will undoubtedly represent a major step change for those authorities that currently operate ANPR camera-based enforcement systems and an entirely new and significant challenge for those authorities that don't already operate such systems.

It is therefore important to ensure that there is sufficient staff resource available to meet the operational demand and that these staff are fully trained in the operation of the LEZ and fully prepared for the likely impact of LEZ operation. This is particularly important during the first few weeks of operation when the LEZ will be unfamiliar to road users and when the system is being used in a 'real world' situation for the first time. This is likely to place a significant burden upon LEZ operators, enforcement staff and others (e.g. customer services and other public-facing staff) to respond quickly to any issues – whether technical or arising as a result of public reaction to the LEZ – in order to maintain effective LEZ operation. This impact can be mitigated to a large extent by ensuring that operational processes and procedures are robust and clearly defined and by engaging in thorough systems and staff testing and training involving all aspects of the LEZ System.

Operational Procedures

The operator of the system should document their operational procedures in a series of Standard Operating Procedures (SOPs). These SOPs should be reviewed by the local authority to ensure common understanding. Further details on monitoring performance and routine maintenance tasks are outlined in Appendix G.

Processing of Penalty Charge Notices

Role of the Independent Adjudicator

The Low Emission Zones (Emission Standards, Exemptions and Enforcement) (Scotland) Regulations 2021 set out a process for any scheme user who believes that they have been incorrectly sent a PCN. This starts with the PCN recipient making a representation to the PCN issuer. If this representation is refused, they have the right to make an appeal to an independent adjudicator.

For LEZ schemes, the adjudicator will be the First-tier Tribunal.

Adjudicators are not technical experts and they will look to the CoAD approval for any system used to create a PCN and would usually dismiss any claims by scheme users of inaccuracy or tampering if the system is shown to be compliant.

Maintenance and Support

It will be important to ensure that comprehensive ongoing maintenance and support arrangements are in place for each element of the LEZ System, including communications networks and for the associated non-technical elements such as signage. This should be undertaken alongside the development of clear processes

for systems and communications network monitoring and responses to fault detection/alerts from these systems/networks to ensure that service interruptions are resolved as quickly as possible.

Routine maintenance is a similarly important activity. This should include regular (preferably at least yearly) checks of camera operation to ensure that each camera is operating optimally and to identify any potential points of failure (e.g. damaged housings or components).

Maintenance of signage is critical to ensure that no opportunities exist for successful appeals against PCN payments on the basis of missing, misaligned or damaged signage. For this reason, it is recommended to maintain an up-to-date pictorial and descriptive record of the condition of all LEZ signage. This is similar to the approach commonly employed for existing enforcement activities where clarity of signage is critical to ensure compliance with the regulations and to minimise the risk of successful PCN appeals.

11. Other Issues for Consideration

Data Protection

Article 4 of the General Data Protection Regulation 2018 (GDPR) defines personal data as any information related to an identified or identifiable natural person. Since local authorities can potentially identify the owner of a vehicle from the data captured by ANPR – through the DVLA – authorities should treat ANPR data as personal data. Appendix E provides further information on this issue.

Sharing Data with Police Scotland and Other Agencies

Police Scotland and other Law Enforcement Agencies (LEAs) are major users of ANPR data and find it a very effective aid to law enforcement. The Home Office and the National Police Chiefs Council jointly published it's ANPR Strategy 2020-2024 where it was noted that LEAs active in the area of a LEZ may see it as advantageous to have access to the ANPR data from the LEZ system. There is precedent for this sort of dual use of ANPR systems and it is an efficient use of public funds. It is important to clearly document the requirements for LEZ and law enforcement, recognising the differences whilst maximising the opportunity.

Before authorities share personal data with any third party, including LEAs, authorities should seek advice from the Information Commissioner's Office (ICO) and their own Data Protection Officer (DPO) and ensure appropriate steps are taken to comply with data protection legislation. Such steps should include, but are not limited to, putting appropriate data sharing agreements in place that set out how the data will be processed and how the parties will ensure that they comply with data protection requirements, and an updated Data Protection Impact Assessment (DPIA).

From a technical viewpoint, the police require data to be available very quickly to enable them to act and respond to threats. This is within 2 seconds of capture in most cases and so any data feed will probably have to be directly from the roadside rather than via the local authority's ANPR Back-Office System. The format required by the police is also very specific (see document 'National ANPR Service Technical Specifications') with a limitation on file size. Some ANPR camera controllers have a facility for a dual SIM card for a second Police data feed.

There is also a need for operational procedures to be put in place between the LEZ system operator and the Police to communicate about outages, planned maintenance and technical issues.

From the local authority viewpoint, it is recommended that:

- Police Scotland is contacted at an early stage in the project, to establish if there is any interest from any LEA in an ANPR feed from the LEZ system. The LEA would normally have to establish that any camera location is compliant with their normal criteria for receiving ANPR data, including the conditions set out in schedule 2 (2) of the Data Protection Act 2018.

- If there is interest, or might be interest within the lifetime of the initial contract, it is suggested that the technical requirements for a duplicate Police feed from the ANPR roadside systems are included in the procurement. This is likely to entail:
    - Producing a second vehicle record for every vehicle in the Police format (a Police Passage Record – PPR)
    - Linking a second comms network (to be supplied by the Police) to the roadside equipment
    - Providing a new interface to the Police systems. This could be to the local force or could be directly to the Police National ANPR Service
- Commercial arrangements (who pays for what) should be negotiated and agreed at an early stage with the Police.

Local Authorities should focus on ensuring the LEZ system is fully operational and stable as their first priority, but that once this is achieved, consideration can be given to providing the duplicate feed to the Police.

Appendix A – Terms and Abbreviations

The following terms and abbreviations are used in this document:

ANPR - Automatic Number Plate Recognition (camera)

Back-Office Systems - All back-office systems required for LEZ operation including the ANPR Back-Office System and the Notice Processing System (NPS). See definitions of these below.

CAZ - Clean Air Zone

CCD - Charge-Coupled Device

CMOS - Complementary Metal-Oxide Semiconductor

CoAD - Certification of Approved Devices

Confidence Factor - A value provided by an ANPR system against each ANPR 'read' indicating the probability that the 'read' is correct

CT - Completion Testing

Defra - Department for Environment, Food and Rural Affairs

DfT - Department for Transport

DPA - Data Protection Act 2018

DPIA - Data Protection Impact Assessment

DPO - Data Protection Officer

DVLA - Driver and Vehicle Licensing Agency

ERCU - Evidence Retrieval and Control Unit

FAT - Factory Acceptance Testing

FoV - Field of View (of ANPR camera)

GDPR - General Data Protection Regulation 2018

GPS - Global Positioning System

HOTA - Home Office Type Approval

ICO - Information Commissioner's Office

IR - Infra-Red

JAQU - (UK Central Government) Joint Air Quality Unit

LEA - Law Enforcement Agency (see list of LEAs in the document 'National ANPR Standards for Policing and Law Enforcement')

LEZ - Low Emission Zone

ANPR - Back-Office System System for the processing of captured VRM data and including interfaces with external systems for vehicle compliance checking; also includes facilities for reviewing potential LEZ contraventions and provision of contravention records to the NPS for processing of PCNs.

LEZ System - All roadside equipment required for vehicle detection (i.e. ANPR cameras) together with the ANPR Back-Office System (see above definition) and all communications networks and associated equipment for the exchange of data with external systems (e.g. DVLA database) and with the NPS.

MEV - Mobile Enforcement Vehicle

MSF - A radio time signal provided by the National Physical Laboratory. Formerly known as the 'Rugby time signal'.

NPS - (Penalty Charge) Notice Processing System

OCR - Optical Character Recognition. The process of computer software recognising letters and numbers from an image and interpreting them into a text file.

PCN - Penalty Charge Notice. Sent to keepers of non-compliant, non-exempt vehicles driving within a LEZ.

PPR - Police Passage Record

RFS - Ready for Service (Testing)

SAT - Site Acceptance Testing

SOP - Standard Operating Procedure

TCF - Technical Construction File

ULEZ - Ultra-Low Emissions Zone

UPS - Uninterruptible Power Supply

VCA - Vehicle Certification Agency

VPR - Vehicle Passage Record

VRM - Vehicle Registration Mark ('number plate')

WAN - Wide Area Network

Appendix B – References

The following documents are referenced within this document and/or were used in its production. Consideration should be given to the possibility that these may have been updated since publication of this document.

1. The Transport (Scotland) Act 2019
2. The Low Emission Zones (Emission Standards, Exemptions and Enforcement) (Scotland) Regulations 2021
3. The Low Emission Zones (Scotland) Regulations 2021
4. Principles for setting up Clean Air Zones in England, Defra and DfT, February 2020
5. Civil Traffic Enforcement - Certification of Approved Devices - Low Emission Zone Version
6. Automatic Number Plate Recognition (ANPR) for Low Emission Zone Guidance
7. National ANPR Standards for Policing and Law Enforcement, Ver 2.1, Home Office, November 2020
8. National ANPR Service Technical Specifications, Version 3.0, Home Office, June 2020
9. Guidance on ANPR Performance Assessment and Optimisation, Version 2.0, Home Office, July 2020
10. Automatic Number Plate Recognition (ANPR) Strategy 2020-2024, Version 1.0, Home Office/National Police Chief's Council, April 2020
11. General Data Protection Regulation (GDPR) 2018
12. Guide to the General Data Protection Regulation 2018
13. Data Protection Act (DPA) 2018

Appendix C – ANPR Camera Hardware and Software

Components of an ANPR System

ANPR system elements comprise:

- ANPR camera(s)
- Illuminator
- ANPR Processor
- Communications
- ANPR Back-Office System

ANPR cameras and Illuminators

Under ideal lighting and weather conditions almost any camera can be used for ANPR. However, they will quickly stop operating under less benign conditions such as night, low sun, shadows etc.

It is therefore essential for ANPR systems to use cameras that are designed for this specific purpose. The most usual techniques used by the suppliers for overcoming the problems with regular CCTV cameras is to use a monochrome ("black and white") camera with an infra-red "illuminator" set close to the camera lens; the infra-red light emitting diodes can be mounted around the camera lens. The camera is then heavily filtered to let through the light from the illuminator to be reflected from the vehicle number plate and to block as much ambient (sun) light as possible.

This technique utilises the retro-reflective characteristics of a number plate's background to give a very bright image of the plate against a dark background. This makes it relatively easy for the software to locate the number plate and stops the camera being 'dazzled' by bright sunlight, headlights etc.

The characters are non-retro-reflective and therefore appear dark in the resulting image. This contrast allows the process of Optical Character Recognition (OCR) to work better to determine the letters and numbers comprising the number plate.

The illuminator would normally be required to be invisible to the human eye so as not to provide a distraction to drivers and not to draw attention to the site. In practice this means a light wavelength of 850 nanometres or longer.

Note the requirement in the CoAD standard is for cameras to produce useable images in ambient light of 2.0 lux. This is to cover the situation of a failed illuminator.

The camera exposure control is very important. Most standard CCTV cameras look at a scene average and adjust the camera exposure for this. For ANPR this is not optimal, as the enforcement agent is only interested in the correct exposure on the plate, so the best ANPR camera systems monitor the brightness of just the plate area (the plate 'patch') and adjusts the exposure and illumination based on this.

Some cameras go further and expose each plate at a number of different exposure levels and then subsequently select the best.

Most ANPR systems used for enforcement can also generate a more "general overview" (sometimes called a "context image"). This image shows the whole vehicle so that the make and model can be identified and sometimes also provides a double check on location and the VRM. Overview images may be monochrome or colour, i.e. using near infrared or daylight, however colour images at night will require visible light illumination, preferably white light. In some circumstances this may not be practical or desirable, but in other circumstances it may be practicable to use existing street lighting.

One camera may be able to fulfil the role of both ANPR and overview camera but this approach could mean some compromises in performance.

The camera will produce the timestamp for the record and this timestamp has evidential importance. The camera internal clock should therefore be periodically synchronised to a source traceable to a national time standard clock (e.g. GPS, or the MSF radio time signal). Any large discrepancy between the internal clock and the reference clock upon re-synchronisation should raise an alarm to an enforcement operator and/or system maintenance provider to enable rectification of this error.

For an area-based LEZ, a single image set (one ANPR image and one overview image) – where the vehicle can be clearly identified – showing that a vehicle was moving within the LEZ during the LEZ operating hours would be sufficient for enforcement purposes. It should be noted that this form of evidence would be sufficient in order to obtain a record from the DVLA (noting the reference elsewhere in this guidance in relation to evidential integrity).

ANPR Algorithms and Processors

ANPR algorithms comprise the software that extracts the VRM from the camera image using a process of Optical Character Recognition (OCR). This can be run on hardware in the camera housing itself or on a separate processor.

The software algorithms will be proprietary to a system supplier. Different suppliers use different principles (e.g. neural networks, template matching) with each claiming advantages for their solution. The performance of ANPR algorithms can vary between suppliers so the local authority is advised to seek evidence of levels of performance from other representative schemes.

Some ANPR systems can be triggered purely by a vehicle entering the camera field of view ("internally triggered"). Others may be triggered by the vehicle being detected by an external sensor such as an inductive loop in the road or an overhead laser sensor ("externally triggered"). The benefit of using an external trigger is that the system can produce an image even when the plate finder has not detected the vehicle or has detected the wrong part of the vehicle. In any case, the key importance is the overall output performance of the system.

All ANPR systems will make errors and no system will read plates 100% correctly. Systems may completely fail to detect vehicles that drive past the camera – known as a "missed vehicle" – or misinterpret the VRM of those vehicles it does detect,

known as a “misread”. In some cases a VPR may be produced but it may not be possible to identify the vehicle from the image(s), for example if the plate is damaged or partially obscured. This is known as a “lost vehicle”.

The ANPR algorithm will usually produce a ‘confidence factor’ for each ANPR ‘read’. This is an indication of how confident the software is that it has correctly read the plate. However, confidence factors are not generally highly reliable – some high confidence reads will be wrong and some low confidence reads will be correct. The confidence level is therefore more of a general indication of the probability of the read being correct.

Almost all ANPR systems use the expected plate syntax to obtain a high read accuracy. This means that, in the UK, it would be ‘tuned’ to read UK formatted plates. To obtain a good read rate of non-UK plates it is usually best to specify the nationalities sought so that that nationality’s plate syntax can be included. The ANPR system will still make an attempt to read plates of other nationalities but may try to correct it to the syntax of a known country and will usually allocate it a low confidence factor, which should flag the record for manual image review (this is known as “further processing of the VPR”). The danger of adding too many nationalities is that it may decrease the read accuracy of UK plates, which will comprise by far the majority of vehicles that need to be identified.

ANPR algorithms are ‘tuned’ to nationalities over a long period of use and any glitches are gradually corrected. It is therefore important that any ANPR algorithm has been in use in the UK for a reasonable period of time, e.g. several years.

Finally, it should be recognised that the ANPR read is not a part of the evidential chain in enforcement – the evidence is the image and the associated meta-data (e.g. date, time and location). The ANPR read is just a process whereby compliant and exempt vehicles are filtered out in order to highlight potential contraventions. Therefore, camera image quality is a critically important part of the evidence.

Appendix D – Procurement Specification Minimum Requirements

The procuring authority should specify an ANPR system that produces a VPR for every vehicle that passes through the field of view of the cameras, provided the number plate is readable by the human eye. For fixed cameras, the requirements should indicate a road link that should be monitored whilst mobile systems should be designed based on a distinct capture zone around the vehicle.

ANPR Camera

This element should include the following requirements:

- An ANPR camera system that produces an image of every vehicle passing through the camera field of view such that the VRM can be read by the human eye.
- Any illumination system to not cause any distraction or dazzle to drivers and to be eye-safe. In sensitive areas it may be better to specify illumination that is invisible to the human eye.
- The ANPR camera system to have filtering and an exposure control mechanism to overcome adverse lighting conditions, including night-time, low sun in front or behind the camera, shade and partial shade.
- The ANPR camera to have mechanisms to cope with very dirty and clean plates in the same traffic stream.
- The VPR timestamp must be from a clock that is regularly synchronised to a source traceable to a national time standard clock.
- If a clock shows excessive drift from the reference clock upon synchronisation, this should raise an alarm to the operator.
- The time stamp requirements of the CoAD standard should be adhered to.
- A camera to produce an overview or contextual image of the vehicle, clearly enabling the identification of the vehicle make and model from the front image. This should be during day and night-time. During daylight it may also be possible to determine the colour of the vehicle

The main specification point on ANPR processors is the requirements on ANPR accuracy e.g. the performance of the ANPR. Requirements should however specify an ANPR algorithm that has been in use in a comparable UK application and has demonstrated the required levels of performance.

The specification should also have a list of non-UK origin plates that should be read by the ANPR algorithm.

In general, the requirements for re-deployable and mobile systems are similar to fixed systems. The main differences are in the performance and road coverage.

Camera Coverage

This should provide the following requirements:

- maps and site diagrams clearly indicating the sections of road to be monitored. Exact placement of cameras should be left as open as possible to the suppliers, but it should be emphasised that only vehicles clearly and unambiguously within the LEZ are to be detected.
- It should be clear whether full kerb-to-kerb coverage is required, or some lesser area.
- If full kerb-to-kerb coverage is required, a minimum 0.5m overlap of the FoV of adjacent cameras at the point nearest to the cameras should be specified.
- It is recommended that the local authority decides whether front only, or front and rear ANPR systems are specified (rather than leaving this to the supplier to offer a solution), so that the local authority can compare bids on a like-for-like basis.
- The field of view of the ANPR cameras must be 100% within the LEZ.
- The overview camera should preferably show enough contextual detail to be at a recognisable location within the LEZ, for example by showing proximity to a landmark within the LEZ and/or signage identifying the location as being within the LEZ. This detail is not required for evidential purposes but it may provide further evidence that a contravention occurred within the LEZ if there is a challenge to the issue of a PCN. Reference images should be taken at all sites during installation.
- Any mobile system should establish and record the vehicle's location in accordance with the CoAD standard.
- Any mobile system should have mechanisms to supress data gathering if the vehicle drives outside the LEZ, or when the cameras may be pointing outside the LEZ.

Roadside Infrastructure

This should provide the following requirements:

- All roadside infrastructure and equipment shall be designed to as far as reasonably possible be vandal-resistant. This should include, but not be limited to high security locks, no external hinges on cabinets, no exposed cabling.
- The roadside systems should send in regular 'heartbeat' messages to the ANPR Back-Office System as well as alarms for any unexpected event.
- The roadside system shall be able to store a minimum of 2 days of data in the event of a communications failure.

- In the event of a communications failure, the system shall be able to upload and clear the backlog of data in a time not exceeding the time of the communications outage. In other words, if there was a 2-hour communications outage, the system should be able to clear the backlog of data within 2 hours of the re-connection.
- In the event of a power failure to the roadside system, there shall be an orderly shutdown of the system and it shall automatically re-commence operations upon the restoration of the supply. It may also be wise to specify that a minor power interruption (say < 2 seconds) would not cause the system to shut down.
- The ANPR Back-Office System shall have a Recovery Time Objective of (x) and a Recovery Point Objective of (y). The values of x and y to be determined by the local authority in line with business needs.

ANPR Performance

This should provide the following requirements:

- Minimum capture and correct read rates should be specified in accordance with the levels indicated in Section 3 of this guidance document.
- The test methodology for determining compliance to the capture and read rates should be specified. This would normally be ground-truthing completed once the system has been installed in its final location, as set out in Section 3 of this guidance document and as described in the Home Office document 'Guidance on ANPR Performance Assessment and Optimisation'.
- The sample sizes should also be decided by the local authority to be of statistical significance i.e. the required margin of error.
- The system should operate with vehicle speeds from stopped to 100 mph (or other value if appropriate for the roads)
- The specification should include vehicle flow rates these can be based on recorded traffic on the subject roads, but it is suggested that a significant safety margin is added to allow for future traffic growth, day-to-day variations and increased traffic caused by incidents. These will need to be tested/proven by the use of traffic simulators, as it is likely to be impossible to find the appropriate flows in real life. Suggested default figures would be:
    - a short term rate of two vehicles per second sustained for a period of 30 seconds
    - A long term rate of 2000 vehicles per hour per lane sustained over three hours
- It should be specified that performance is maintained for all types of vehicle behaviour, including queuing traffic, lane changing, swerving etc.
- It should be specified that vehicles should be detected in any lateral position across the road.

- It should be specified that performance is maintained in all environmental and weather conditions likely to be encountered, including but not limited to high and low temperatures, rain, fog, high humidity and snow.
- Tenderers should be asked to describe how their system minimises the effects of the main factors effecting ANPR performance.
- Tenderers should provide relevant technical specifications

Vehicle Passage Records

VPRs should provide the following requirements:

- The minimum contents of the VPR should be set out, although flexibility should be allowed for additional data fields that the supplier may suggest.
- Local Authorities should specify compliance with the CoAD standard in the capture storage and transmission of VPRs.
- The system and operational procedures should process VPRs in compliance with the relevant data protection legislation and should treat them as personal data for the purposes of the General Data Protection Regulation 2018 ('GDPR').
- If there is a likelihood that the Police may require a duplicate data feed at any point in the lifetime of the system, the requirements should contain provision for this, either as the initial supply, or a costed option.
- There should be wide consultation with other potential users of VPR/ANPR data and their own requirements included in the initial requirements. This may include journey time monitoring and origin/destination data. Some of these applications may need measures to 'anonymise' the data to be compliant with data protection legislation.

Downstream Data Processing

This should provide the following requirements:

- The local authority should decide whether the raw ANPR correct read rate is commensurate with their business needs. If not, they need to specify further processing to as far as possible eliminate incorrect reads (sometimes called 'false positives') being passed to the next stage of the process.
- If it is decided further processing is required, it is often best to leave it to the supplier to use the techniques they are familiar with and specify the false positive rate after this processing (through a sample check) or alternatively specify the number of false positives picked up at the pre-PCN manual image review stage, or incorrect PCNs detected through representations.
- Suppliers should be asked to describe any techniques they use for data cleansing prior to sending to the central system.

- Whatever correction techniques are considered, it is strongly recommended that all PCNs are manually reviewed before dispatch for accuracy, using software with similar facilities to that indicated for low confidence image review (see 'Verification and Correction of ANPR Reads Against Images in VPRs' in Appendix F of this guidance document). In particular, the make and model cross-check is important.

Evidential Integrity

This should provide the following requirements:

- The CoAD compliance requirements must be stated in procurement documentation
- The supplier should be obliged to produce the TCF in a timely manner.
- The local authority should decide if they have sufficient expertise in-house to evaluate the TCF. If not, employment of the VCA should be considered.
- Early engagement with the local authority/VCA is to be encouraged.

Operations and Maintenance

This should provide the following requirements:

- SOPs should be created and reviewed by the local authority.
- Levels of support for roadside and back-office systems maintenance should be specified. This should be commensurate with the required availability and hours of operation.
- It should be decided whether a level of spares holding is procured separately or left to the maintenance contractor. If the system provider is also the maintenance contractor, it would normally be best to specify an availability, rather than trying to guess the spares holding required. If a different maintenance contractor is employed, the procuring organisation may need to provide the spares to the provider.

Testing

This should provide the following requirements:

- The local authority must outline what their test strategy will entail, following the detail outlined in Appendix H.

Appendix E – Data Protection and Privacy Issues

Data protection issues must be considered when configuring and managing the use of ANPR and associated data handled. It is for local authorities to ensure that they are meeting the requirements of data protection legislation and should seek advice from their legal team and data protection experts before procuring and using their LEZ systems.

The key requirements of data protection legislation are set out in the General Data Protection Regulation 2018 ('GDPR') and the Data Protection Act 2018. In summary, the key principles are that personal data must be:

- processed lawfully, fairly and in a transparent manner ('lawfulness, fairness and transparency')
- collected for specified purposes and not further processed in a manner that is incompatible with those purposes ('purpose limitation')
- adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed ('data minimisation')
- accurate and, where necessary, kept up to date ('accuracy')
- kept for no longer than is necessary for the purposes for which the personal data are processed ('storage limitation'); and
- processed in a manner that ensures appropriate security of the personal data, using appropriate technical measures ('integrity and confidentiality').

A data controller is responsible for the collection and processing of personal data and must be able to demonstrate compliance with the principles listed above ('accountability').

A data controller is the person, public authority or other body that determines the purposes and means of processing personal data. A data processor is the person or body that is responsible for processing personal data on behalf of a controller. Local authorities are therefore likely to be data controllers in relation to any ANPR data. They should therefore ensure that they comply with data protection legislation, including the GDPR principles listed above, but also put procedures and contracts in place to ensure that any data processors, who may collect and/or process personal data on the local authority's behalf, also comply with data protection legislation.

The Data Controller should complete a DPIA before the implementation of the scheme.

Further to the above, authorities might also want to consider the following:

- Where a VPR is matched to an exempt or grace period vehicle list there is probably no reason to keep it.
- Where there is no exemption or the grace period has passed, there may be a need to keep the VPR until a payment against a PCN is received and any time limit for any subsequent representation or appeal has passed.

- Unlike CAZs and the London ULEZ, LEZs in Scotland are not charging schemes. Instead, a penalty charge notice will be issued if a vehicle travels in the LEZ in contravention of the LEZ regulations. In addition, where multiple contraventions occur relating to that vehicle, penalty charge surcharges are applied. This surcharge doubles for each subsequent contravention relating to that vehicle that occurs within 90 days of the previous contravention, up to a maximum surcharge for five or more contraventions. A local authority will therefore need to retain data on how many contraventions have occurred for a specific vehicle within a 'rolling' 90 day period in order to ensure that the correct penalty charge and any associated surcharges are applied.

- Consideration should be given to what management information data may be required and whether any of this may require anonymisation or aggregation of personal data so that it may be retained.

- Consideration should be given to any dual use of the data. The use of the data by Police is discussed elsewhere (see Section 11) but, for example, a local authority may wish to build a picture of how frequently vehicles use the LEZ and may wish to use the data for journey time monitoring and/or origin and destination journey data. The data protection aspects of this type of use should be carefully considered.

Appendix F – Downstream Processing of VPRs

Verification and Correction of ANPR Reads Against Images in VPRs

The process to identify and correct incorrectly-read VPRs may be as follows:

- The system evaluates each VPR and decides if the read confidence is high enough for automatic processing.
- If read confidence is not sufficiently high then the VPR is passed to a manual image review queue.
- For each VPR in the manual review queue, an enforcement operator will compare the ANPR image with the ANPR read (or, better still, use blind entry – see 'ground-truthing' in Section 3 of this guidance document) and, if necessary, correct the VPR.
- Once corrected, the enforcement operator passes the VPR for further automatic processing.

Manual Review of VPRs

The image review software is a special application, which should include a feature to present the operative with the vehicle make, model and colour from the DVLA data associated with the VRM. This should also include controls to change the brightness and contrast of the images if required.

Manual image review with suitable software can be a quick and accurate process. Experienced and well-trained operatives can process over 2,000 reviews per day.

It is good practice for the manual image review process to record the date and time of the image review and the identity of the reviewer and, if the VRM is updated by the operative, to keep the original read and the corrected VRM. This helps to identify any systematic errors by the ANPR algorithm and also helps to identify areas for improvement in the performance of operatives in the manual review process.

The evaluation of the VPRs for low confidence manual image review is a critical process. Even though 5% of the VPRs may be incorrect, anything up to 20% of VPRs may have to be checked to identify the incorrect 5%. Anything that can be done to automatically sort actual incorrect reads from correct reads is very worthwhile. The techniques described in this guidance document should assist in that process. The 'default' technique is to simply to base the decision on the confidence factor that the ANPR system provides.

Automatic (System-Based) VPR Processing

De-Duplication

There is a good chance of the same vehicle being identified by multiple ANPR cameras more than once in a day. A simple filter can be implemented to manage the incoming VPRs such that, if the same VRM has been identified previously during that period, then just the VPR with the highest read confidence is retained.

Filters and Flags

Some systems use a series of filters to filter out some of the VPRs that are almost certainly unusable. Example of these include:

- Common false trigger filter – would filter out reads of “TAX1” for example, or where the ANPR reads the sign on the front of a bus or truck.
- Partial plate filter – part of a business rule such that if the number of identified characters is below a certain value and the VRM does not appear in the DVLA database then the record is discarded, as it is almost certainly the system reading a partially obscured plate.
- Common misreads flag – where a plate has been misread by the ANPR, with high ANPR confidence, the misread VRM is added to a list of common misreads and will be automatically flagged for image review each subsequent time it is identified.

Fingerprinting

Fingerprinting is a technique for gaining confidence in a correct read. Some ANPR suppliers are, in addition to creating the ANPR read, producing a digital vehicle 'fingerprint'. This fingerprint is meaningless in itself but the system creates a database with the VRM (if known to be correct) and the related fingerprint.

When the vehicle is seen again, the system looks for the fingerprint associated with the VRM that has been read. If the VRM read and the fingerprint match then the ANPR read is almost certain to be correct and the record can be processed automatically. This technique works best where there is a high proportion of regular repeat users.

Multiple ANPR Algorithms

Some systems take the ANPR image from the roadside detection equipment and may pass it through a second, third or even fourth ANPR algorithm (known as 'secondary ANPR'). This works best if the second or subsequent algorithms use a different principle for OCR than the primary (roadside) ANPR.

The results of all of the ANPR reads are evaluated using business rules (usually a form of 'voting system') and a determination is made as to whether a manual image review is required.

Compliance and Exemptions Checking

Once any review and correction action has been taken, the VPR is then processed to establish compliance or exemption status of the vehicle. This process is described in Section 4 of this guidance document.

Appendix G – Operations and Maintenance

Monitoring Performance

With a large quantity of roadside and associated equipment, it is important that a process of automatic monitoring of performance is in place. For roadside equipment this should include as a minimum:

- Monitoring of 'heartbeat' and alarm messages from the roadside equipment and alerting an operator to any unusual events
- Monitoring for any attempted or actual unauthorised access to roadside or back-office systems
- Periodic ground-truthing, or at least regular (e.g. annual) performance monitoring of each ANPR camera site, as described in the Home Office document 'Guidance on ANPR Performance Assessment and Optimisation'

Other monitoring that may be considered includes:

- Monitoring of long-term trends in some values to look for anomalies or for long-term degradation of performance. Examples include monitoring of trigger rates and average ANPR confidence.
- Some systems automatically compare a daily image from each camera with a reference image to see if the camera has been knocked out of alignment.

Routine Maintenance

It is obviously desirable to minimise routine maintenance in order to minimise operating costs and potential disruption to traffic, in addition to reducing any site-based risks to maintenance operatives. The following are considerations to reduce the routine maintenance of what may be a large volume of roadside equipment:

- Camera faceplate cleaning may be minimised by the provision of a 'hood' on the camera that has an area of still air in front of the faceplate. Such a hood should not of course encroach on the field of view.
- Regular cleaning of the camera faceplate may be necessary, particularly if the camera is near a road known to create a lot of dirt, to ensure the camera view is kept clear and the ANPR system is always capable of performing optimally.
- Automatic wash-wipe systems should be avoided if at all possible. The advantages of such systems in maintaining clear vision are generally considered to be outweighed by the disadvantages of requiring regular maintenance and being prone to failure.
- Replacement of cameras can be undertaken without the need to realign the camera if 'memory brackets' are used.

- Consideration should be given to safe parking for a maintenance vehicle near to each site.
- Roadside post mounting sites have fewer requirements for traffic management than cantilevers or gantries.
- The installation of cameras on 'winched' or 'tilt-down' mounting posts reduces risks to maintenance operatives in working at height as well as reducing the need for vehicles and elevated platform machinery (and associated pedestrian and/or traffic management measures).
- Consideration should be given to being able to update camera and roadside processor software and firmware remotely over the communications network, reducing the need for attendance at site and the possible need for operatives to work at height.

Emergency Maintenance

The required availability of an ANPR enforcement system as described in this guidance document may be greater than other CCTV systems, as a non-functioning system may potentially undermine the objectives of the LEZ scheme. The following issues should therefore be considered:

- It is important to hold an adequate stock of all spares, including cameras/illuminators, supporting infrastructure and communications elements.
- There may need to be a 24/7 on-call maintenance provision. This is not only to restore sites to full operation quickly but may be, for example, to make a site safe after a road traffic incident.
- It may be useful to have available some form of emergency re-deployable or mobile ANPR equipment to fill-in while a damaged site is restored.

Appendix H – Testing

Test Phases

The local authority should consider what degree of testing is needed, what testing is required to witness and to what degree the system supplier can conduct testing to the local authority's satisfaction.

Testing should cover the roadside equipment as well as the ANPR Back-Office System. This should include any data cleansing and image review as well as the controlling of the flow of data to and from ANPR Back-Office System.

The following are some recommended guidelines on test phases.

Initial Type Testing

Predominantly for roadside equipment, this is to demonstrate the basic performance of the equipment. It should cover as a minimum:

- The accuracy and performance under a mixture of traffic conditions. This might be proven through other representative sites or through a test site. Some tests will be done on a traffic simulator.
- Environmental resilience of the equipment – resistance to heat, cold, damp, shock, vibration etc. The supplier may have data from previous testing or may have specific tests carried out. Local Authorities may also specify a degree of Ingress Protection (IP) to protect the insides of systems from fine particle or water when they are permanently based outside.
- Ability to read foreign number plates (if required)

Factory Acceptance Testing (FAT)

This also relates to roadside equipment. Every unit coming from manufacture should undergo a FAT to ensure that it is of the same build standard as the units in the initial type testing.

Unit Testing and System Testing

This relates to the in-station software. Each software unit is tested by itself and then tested as a whole in-station system.

System Integration Testing (SIT)

As part of SIT, the entire system, including roadside equipment and the ANPR Back-Office System, is put together and connected to all external systems (e.g. DVLA database). Where real interfaces are not available then they should be replaced by simulators/test harnesses.

Site Acceptance Testing (SAT)

Each roadside site should undergo a SAT whereby the accuracy of each site is proven through ground-truthing. Integration of the site to the ANPR Back-Office System should also be tested.

System Proving

This is where the final system is run for a pre-defined period to check for stability and effective operation under varying load and fault conditions. It should involve introducing simulated faults and checking system resilience and recovery.

Penetration (Pen) Testing

Penetration (pen) testing is carried out prior to final commissioning. It comprises a series of tests to simulate a cyberattack on the LEZ System. This is intended to verify whether the LEZ System is sufficiently secure to withstand genuine cyber-attacks and to identify any security vulnerabilities that would need to be addressed prior to LEZ operation.

Ready for Service Testing (RFS)

If system proving is about stability and performance of the system, then ready for service (RFS) testing is about the operational procedures that support LEZ operation and maintenance. RFS testing should ensure all the SOPs are in place and have been thoroughly tested for practicality. It should ensure that all staff involved in LEZ operations have the required training and that all operational procedures with relevant external parties are in place and working effectively.

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