Thermal Roof Markings for Police Vehicles

(Vehicle Roof Markings Update)

Home Office
BUILDING A SAFE, JUST AND TOLERANT SOCIETY

Publication No 43/04

Updated 2014

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POLICE SCIENTIFIC DEVELOPMENT BRANCH

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FIRST PUBLISHED 2004
UPDATED 2014

Published by:

Home Office
Centre for Applied Science and Technology
Sandridge,
St Albans
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COVER PHOTOGRAPH
Comparison between standard and the proposed roof markings.

Management Summary

This report updates the PSDB Report 1/96 ‘Standard Roof Markings for Police Vehicles’ in order to take advantage of new materials offering the ability to discern the markings using thermal imager equipment. The new markings allow recognition of vehicles as police as opposed to general public at considerable range, and allow the vehicle usage and identification markings to be read at closer range.

The markings themselves are passive in nature, requiring no activity on the part of the air observer or vehicle crew, nor any power from the vehicle. They remain effective when mounted on magnetic backings, so can be temporarily affixed to non-liveried vehicles as required.

It is recommended that the new markings are applied to vehicles as the fleet is updated, rather than immediate adoption on all vehicles.

As an added bonus they will be consistently legible regardless of the vehicle’s paint colour, thus allowing fleet managers greater latitude in purchasing vehicles in colours other than white.

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1 Background and Methodology

This work stems from a requirement placed upon PSDB by the Technical and Training Committee of ACPO Air Operations. Recognising and identifying police vehicles amongst other traffic had been highlighted as a difficulty facing air observers, particularly when operating at night. Colour images show the flashing blue lights but other details are lost, the thermal camera image would show the vehicles and surroundings, but the livery and roofbar lighting could not be seen. The preferred solution would be to make the police vehicle distinguishable when viewed with the thermal camera.

A number of potential solutions were considered, each of which possesses a balance of benefits and drawbacks:

- Passive markings placed on vehicles - new materials are becoming available which could allow recognition markings to be applied. With the UK Police fleet numbering over 30,000 vehicles the cost per unit would have to be very low.
- Active beacons on vehicles – there is potential for achieving visibility at some miles range, but the power drain on the vehicle electrical system could be unacceptably high. Legislation covering the design, construction and fitting of electrical equipment to vehicles may make development of the units prohibitively expensive. Such a beacon would require a unit to be mounted on the vehicle roof in addition to the roofbar lighting.
- Automatic detection of strobe lights - early work focussed on a system aboard the aircraft that detects the flashing lights and overlays the information onto the thermal camera picture. It would only work when the vehicle lights are on, and could be easily confused by other lights in the scene. Also, the proposed system would not have been compatible with the imaging systems aboard many current aircraft. The development cost and cost per unit would be high.
- Fusion of thermal and colour images - a system that merges information from the thermal imager and colour camera to provide the best information from each. This method offers enhanced imagery which can improve effectiveness when carrying out other surveillance and search tasks. Thermal signatures of persons under foliage cover could be seen during the day, as could colour information at night.
- Automatic location from radio positioning - integrating GPS positioning equipment with the Airwave radio system could offer the potential to provide location information from handsets and mobile radios. This information could be interpreted and markers placed on the map display aboard the aircraft.

The ratio of vehicles to aircraft is approximately 30,000:50 (or 600:1), and the operational lifetime of an aircraft is 3 to 4 times that of a vehicle. As a result the potential difference in cost between aircraft and vehicle mounted equipment which would provide equivalent value for money could be of the order of 200:1.

1.1 Technical Background

Thermal imaging cameras form pictures in which the brightness of objects in the field of view is related to their temperature. The thermal radiation emitted from a surface rises as its temperature increases so hotter objects appear brighter in a thermal image (when the camera is set to white = hot).

Another factor which affects the appearance of objects in an image is their emissivity, a measure of how much thermal radiation they emit at a given surface temperature. At

the same surface temperature a low emissivity surface emits less radiation and appears to be cooler than a high emissivity one. Different materials have different emissivity values, as shown in the table below. The emissivity value is the ratio of the output from the surface under consideration and a perfect 'black body' radiator, which has a value of 1. A surface emitting no thermal radiation has an emissivity value of zero.

Material	Emissivity
Painted Surface	0.8 to 0.9
Concrete	0.6
Rusted Steel	0.6
Clean Mild Steel	0.3
Polished aluminium	0.02

Table 1. Sample emissivity values for common materials.

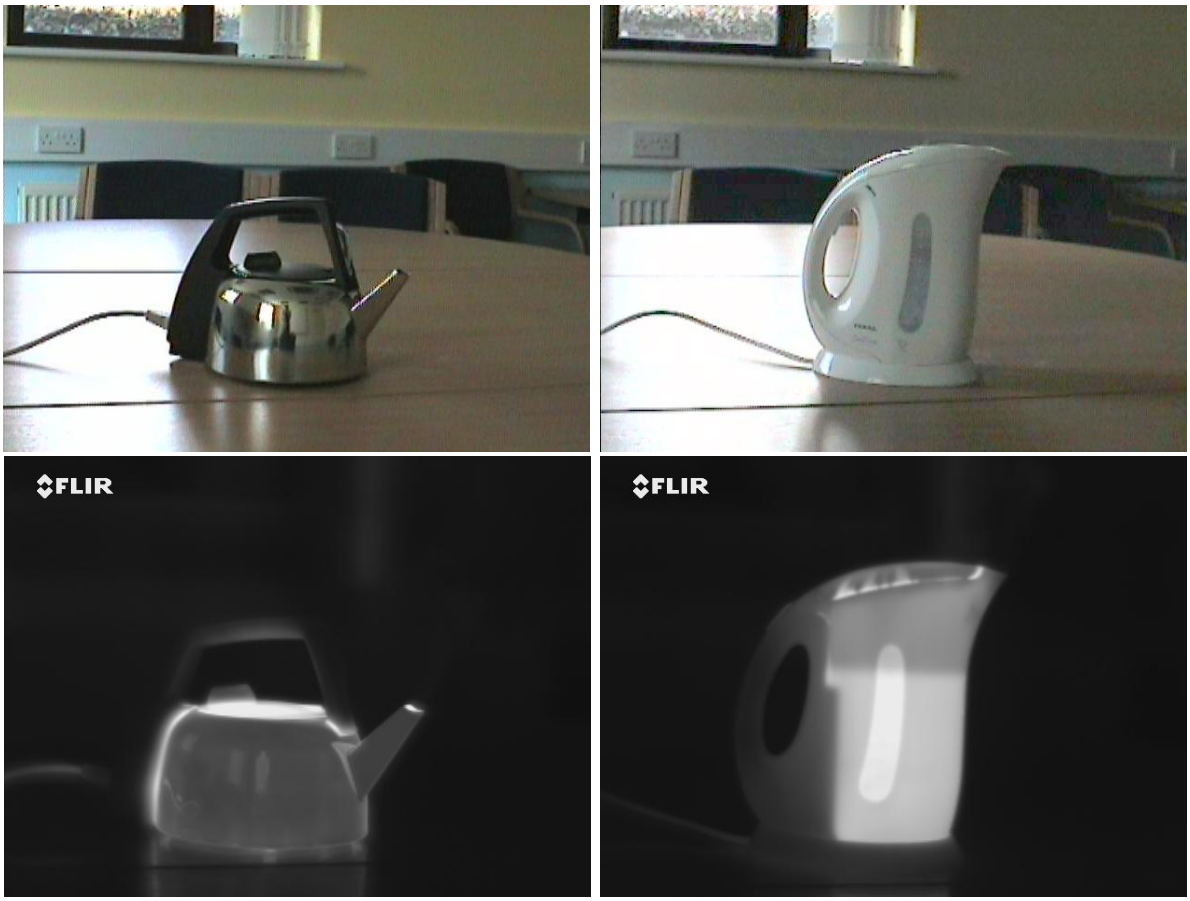


FIGURE 1 ***Colour and thermal camera pictures of metal and plastic kettles.***

In the example of the two kettles the polished metal one appears cooler than the plastic one, in each case the water inside the kettle is boiling. The area of the plastic kettle in contact with the hot water can be distinguished from the slightly cooler part of the body above the water level.

The retro-reflective materials used for police vehicle livery have similar emissivity to that of the paint covering the vehicle bodywork. As a result liveried and non-liveried vehicles look similar when viewed through a thermal imaging camera. The small difference between the two surfaces is insufficient to act as a means of identifying the livery from the background.

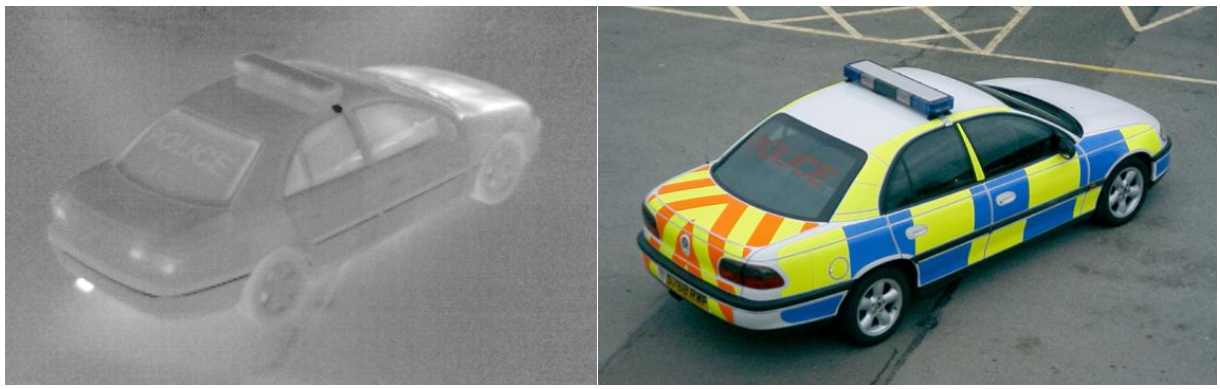


FIGURE 2 ***Standard retro-reflective livery materials do not show up on thermal camera images***

By introducing areas of different emissivity to the paintwork, it is possible to add thermal contrast and improve detection with the thermal camera.

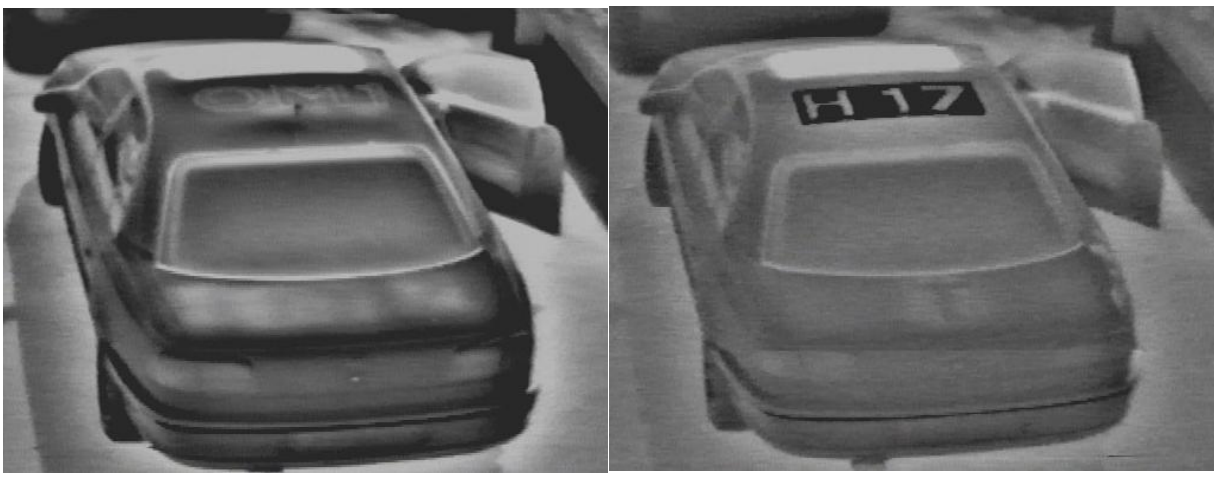


FIGURE 3 ***Standard retro-reflective and prototype low emissivity roof marks compared***

The material now recommended for use comprises an adhesive-backed plastic film with a thin layer of metal deposited on the surface. A layer of visually black but thermally transparent ink is then printed over the metal surface, this allows it to be easily seen both by eye and using a thermal imager.

Low emissivity materials based on a metallised surface also act as a reflector of thermal energy. When placed on a horizontal surface and viewed from above it appears cold due to the reflection of the sky. The reflection of the cold sky along with the lower level of emitted heat from the surface makes the low emissivity material appear to be cooler than the surrounding surface.

Such materials would be ineffective when used on the sides of the vehicle. The material would merely reflect the heat emitted from the road surface, which would not be too dissimilar to that from the vehicle.

1.2 Potential Causes of Reduced Efficiency

Beads of standing water on the surface of the film can reduce the effectiveness of the markings, as they scatter the reflected image of the cool sky. Additionally the thermal camera may be detecting the radiated heat energy from the water droplets rather than that from the underlying surface. In use, the slipstream of a moving vehicle should reduce the build-up of water droplets.

Because a significant proportion of the thermal contrast comes from reflecting the cold sky, in situations where a warmer object is being reflected the marking will be less visible. If a vehicle with the thermal film roof markings is parked under a tree then the reflected heat from the tree might be seen, rather than the cool sky. This would cause the contrast between the film and the car roof to be reduced, impairing the film's effectiveness. In the worst case this would reduce the marking's thermal visibility to that of the old roof markings. The visual effect seen by eye or via the colour camera would still be improved over the old type of markings.

The area of the roof covered by the low emissivity film will be less able to radiate its heat than the surrounding area. As a result there will be a slight temperature rise of the roof panel under the film. In cases where a large proportion of the surface area of an object is covered with this type of material the reduced ability to dissipate heat can lead to the object becoming overheated. In the instance of roof markings the temperature rise will be minimal because the area covered by the film is a small proportion of the total roof area.

2 The Proposed Changes

2.1 Materials Selection

Using a white character against a dark background gives high contrast which has the best chance of being read either directly by eye, or using the aircraft colour camera system. The controlled colour of the background allows for maximum effectiveness no matter what the base colour of the vehicle may be. It also allows for deletion of the character edging strips which previously assisted the character outline to be seen. As a result the effective width of the characters is increased, which further enhances their legibility.

The original guidance in PSDB report 1/96 suggested that the roof marking characters be made from the same retro-reflective materials as the rest of the vehicle livery. The characteristic of retro-reflective materials that makes them useful for vehicle liveries is that they reflect light straight back in the direction it came from. They are particularly effective when the light source and viewer are close together - as is the case with a driver and their car's headlights. In the case of viewing from the air, the reflective nature of the materials is of little value over a plain coloured character unless illumination is being provided by the aircraft.

The reflective layer may be a metallic film, or made from a plastic film that has been formed to make small prisms. Materials using the plastic reflective layer can be quite translucent, and rely in part on having a light coloured background to give good reflective performance. For the purposes of roof markings where the contrast between the character and the background is important, retro-reflective materials which use a metallised reflector can offer better performance than those using a plastic retro-reflective layer.

Non retro-reflective white materials such as Fablon have good opacity and also have good contrast in both the visible and thermal images. The lack of retro-reflectivity is

not too much of a disadvantage for a roof marking because the characters are rarely lit from the same location as they are viewed. Only in the case of the spotlight being used to identify a police vehicle would the retro-reflective material show any slight advantage.

2.2 Character Shape

To maximise the legibility of the characters making up the markings it is recommended that they conform to the 'Transport Alphabet'. The font shapes are defined in the Transport Signs Regulations and General Directions Statutory Instrument 2002 No.3113. Schedule 13 Part 1 shows standard shapes for white on black upper case letters and numbers, with the background widths proportional to the character widths.

This font was developed for use on road signs to provide a clear character set which can be easily read at distance. The characters can be easily produced on modern computer controlled cutting equipment as used by sign makers, vehicle livery and traffic sign manufacturing companies.

2.3 The Force Identification Marking

To date both the PNC and MACC (Mutual Aid Co-ordination Centre) Codes have been used to identify to which police force a vehicle belongs. Although the MACC is now defunct, the codes, based on sequential numbering of an alphabetical listing of English and Welsh forces, have survived as a roof mark identifier (and on officers public order protective equipment) in a number of forces.

2.4 Vehicle Usage Symbols

It is recommended that the standard set of symbols from the original PSDB Report 1/96 'Standard Roof Markings for Police Vehicles' (see Appendix A) need not be changed, they have been used successfully for some time and any alterations would cause confusion during any hand-over period. Additional symbols for vehicles which are not currently allocated a specific marking should be agreed nationally to avoid confusion.

2.5 Vehicle Identifiers

Various different forms of unique vehicle identifier are currently in use. In some cases the vehicle’s fleet number is used, in others a call sign is used. These codes may have different formats of letters / digits between force areas. Whichever system is used, there should be a 'repeater' marking inside the vehicle where it can be read by the crew. There have been anecdotal reports of vehicle crews having to halt, get out of the vehicle and read the roof markings so that they know their call sign.

3 Non-Liveried and Temporary Usage Vehicles

The recommended materials can also be used on panels of magnetic backing material when required for use on unmarked vehicles or traffic vehicles used temporarily as ARVs. The magnetic panels need only be placed on the roof to be equally as effective

as the permanent version of the markings. It is recommended that the temporary panels be used in the same locations and layouts as the permanent markings shown in Appendix B.

Vehicles used by the National Crime Squad could also carry a magnetic backed panel of the material. When operating covertly the panel could be stored inside the vehicle, and when operating overtly they could be placed in much the same manner as existing magnetically mounted warning beacons. The low profile of the marking film and backing could also allow their use whilst operating covertly. The likelihood of the marking being seen by the occupants of the subject vehicle is small, although anyone able to view the roof of the car (pedestrians, those in taller vehicles, etc) would be able to see that a panel was in place.

4 Summary of Recommendations

(i.) Thermally reflective material should be adopted as a background for roof markings,

(ii.) The colour of markings should be white characters on a black background,

(iii.) The Transport Alphabet font should be used to maximise legibility,

(iv.) The PNC number should be used as the force identifier,

(v.) The roof markings should be repeated inside the vehicle for the benefit of the crew.

(vi.) Additional vehicle usage symbols for new categories should be defined and agreed nationally.

The format of the unique vehicle identifier may still be at the discretion of the individual force.

The vehicle usage symbols remain unchanged from PSDB report 1/96. (See Appendix A.)

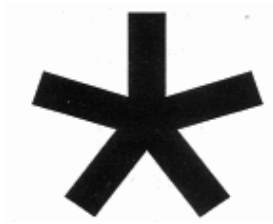
5 Bibliography

The Traffic Signs Regulations and General Directions.
Statutory Instrument 2002 No.3113
ISBN 0-11-042942-7
The Stationary Office
P.O. Box 29
Norwich NR13 1GN

Standard Roof Markings for Police Vehicles
PSDB Report 1/96
Authors: Geoff Knupfer and Adrian Thomas

Appendix A
Symbols to Denote Vehicle Use

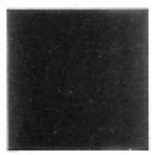
Armed Response Vehicle



Traffic Vehicle

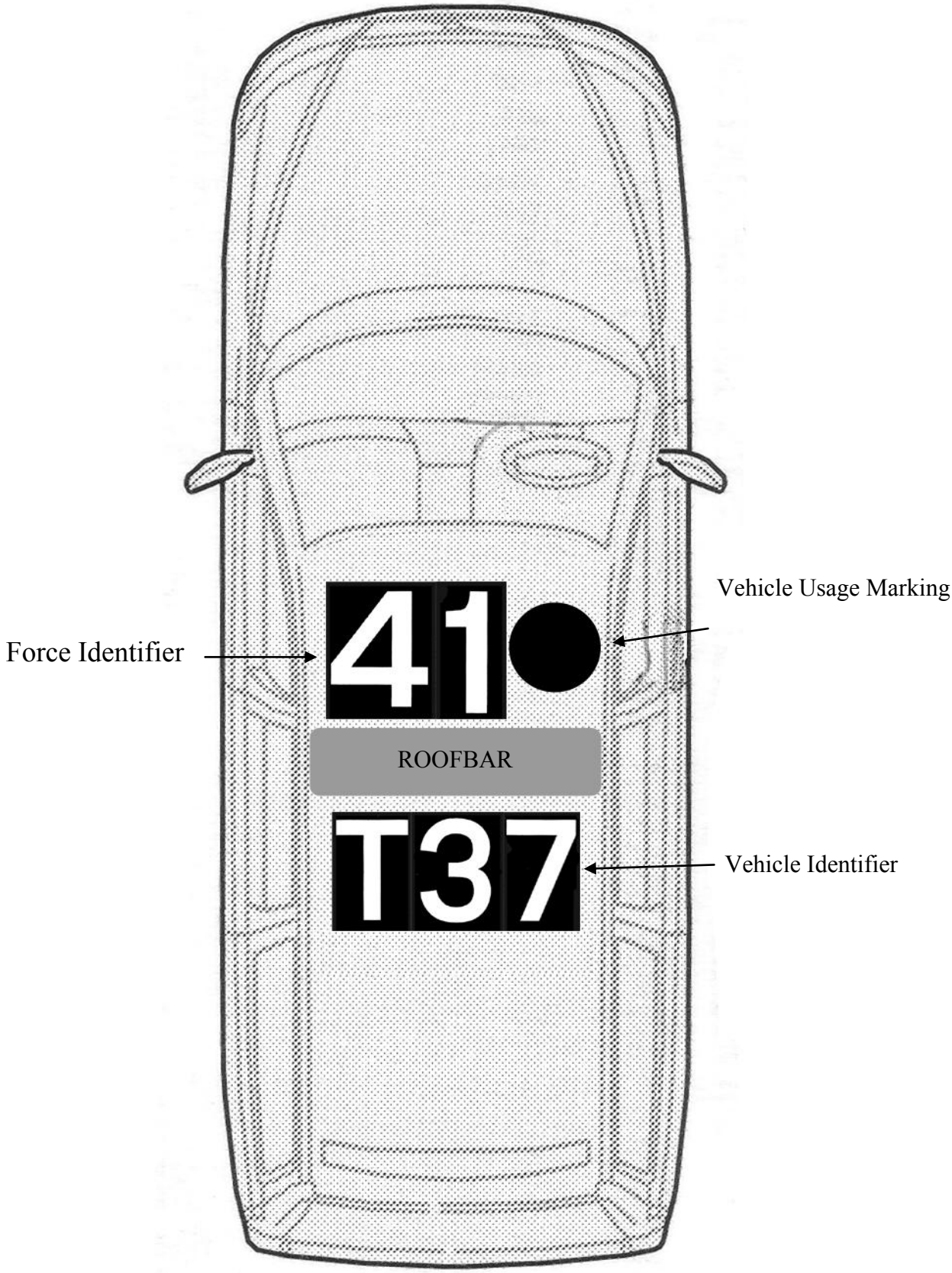
Dog Vehicle

Public Order Vehicle



Appendix B

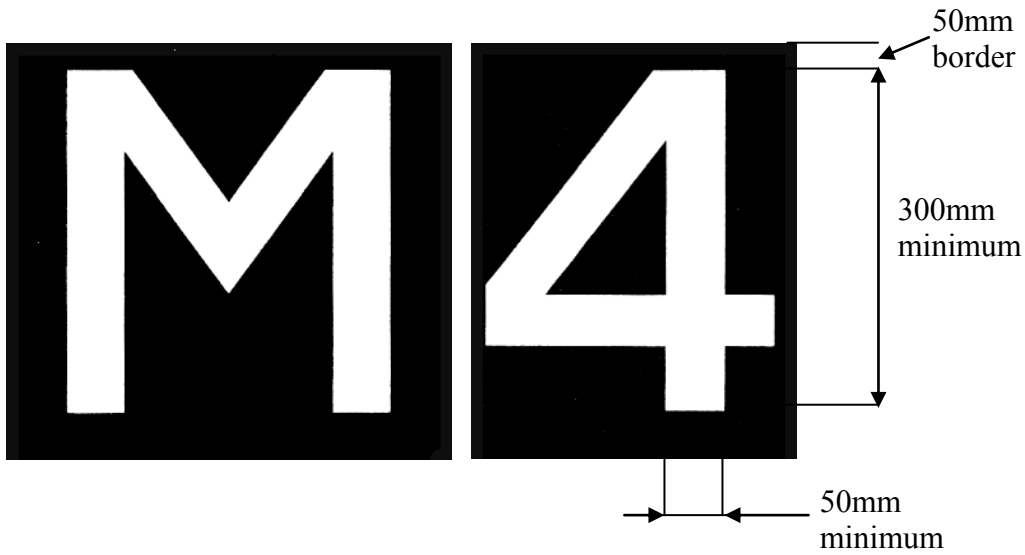
Typical Vehicle Roof Layout



Appendix C

Dimensions Of Roof Marking Characters

The characters should be not less than 300mm in height, this will give a stroke width of approximately 50mm. The height of the backing panel should provide borders of 50mm above and below the character. The proportional spacing of the Transport Alphabet font will govern the widths of the panels.



Appendix D

Supplier of Materials

PVL UK Ltd
24 Victoria Way
Burgess Hill
West Sussex
RH15 9NH

www.pvluk.com/mirage

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