

**APRS Installation for Public Service Events**

**By Bob Clinton W0BUX / G0BUX**

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## 1 Introduction

The usefulness of the Automatic Position Reporting System (APRS) in public service communication has been amply demonstrated in the 15 years since its inception. APRS can perform a valuable role in both planned events and real emergencies. Many amateurs have mobile APRS installations which can be used in these situations but the utility of the system is greatly amplified by the ability to install APRS units on an *ad hoc* basis, in event vehicles or temporary static locations. The purpose of this document is to describe the practices and processes involved in such *ad hoc* installations. Permanent installation in amateur radio stations is outside the scope of this document, as is the design and construction of APRS units.

The term “event” in this document is used to refer to any occurrence involving amateur radio public service communication, whether it is planned (e.g. a sponsored bicycle ride) or an actual emergency (e.g., a flood or hurricane).

This guide is based on the author’s experience installing APRS equipment for events in the USA and the UK. I am grateful to Roger Ferrand G7VBR for reviewing the draft of this paper and for his valuable additions to it.

## 2 APRS Units

There are three categories of APRS units that may be involved in any event. Some events may require two or three categories, others only one.

### 2.1 Trackers

A tracker is a portable unit capable of being installed in an event vehicle (or occasionally on the person of an event participant). Trackers have the capability of (a) determining position using GPS, (b) formatting the position data for APRS transmission, and (c) transmitting APRS data packets at specified intervals. Generally trackers do not have and do not require the capability of displaying position information, either of themselves or other units.

Tracker equipment falls into two categories:

- Category A – “toolbox tracker” – a combination of mobile amateur transceiver, tracker device, external GPS receiver and battery (typically about 7 AH). Such trackers are commonly housed in small tool boxes or similar enclosures, with the battery contained inside. This type of tracker is usually capable of ten or more watts output power.
- Category B – small tracker device such as a Beeline BLGPS which combines transmitter, GPS receiver and APRS logic in one package. The battery powering the device may be either self-contained or separate. Such devices are capable of five watts output power or less.

Figure 1 shows two examples of trackers. A toolbox tracker is on the left, a Beeline BLGPS is on the right.



**Figure 1 - Two Trackers**

### **2.2 Control Station Units**

A control station unit is one that is established to receive position reports from trackers and display them in a medium that permits event managers to make use of this information. In some cases there will be a permanent APRS control station installation, such as at an Emergency Operations Center. For most events, however, the event control station will have to be established just for that event. The APRS control station may only have the capability of receiving, displaying and logging tracker positions, though a transmission capability may also be useful, for two reasons: (a) for generating APRS objects for transmission to other stations, and (b) for sending APRS text messages. Although *ad hoc* trackers will usually not have the ability to exchange APRS messages, many amateurs with permanent mobile installations may have this function available in their vehicles.

The APRS control station will usually be co-located with the voice radio net control station, though this may not always be the case. For some events control stations have been installed in the event operations centre with the APRS display projected on a screen. This has proved to be very useful to event managers.

### **2.3 Digipeaters**

Digital repeaters (digipeaters) are used to extend the coverage of an APRS network by receiving position reports and retransmitting them at higher power or through more effective antennas. If the geographic extent of the event is large or the terrain particularly difficult, then digipeaters may be necessary to obtain effective coverage. In many actual emergencies there may not be time to deploy digipeaters but for planned events they can usually be set up if required.

### **3 Criteria**

These are the criteria for a successful APRS installation:

1. *Safety* – the unit must not create any safety hazard for the occupants of the vehicle nor cause any distraction to the driver.
2. *Security* – the unit must be installed so as to prevent loss or damage to the equipment.
3. *Installability* – the units must be designed so as to permit quick installation. In most cases, installation of a tracker in a vehicle should be accomplished within approximately five minutes.
4. *Compliance* – installations must not violate any regulations (e.g., FCC, OFCOM) or laws relating to vehicle operation.
5. *Operability* – units must be installed so as to permit them to operate according to design specifications.
6. *Integrity* – units must be installed so as to prevent accidental changes to operating parameters or to invite unauthorised people to tamper with them.
7. *Durability* – the installation and the units themselves must be resistant to adverse weather and to moderately rough handling.
8. *Longevity* – the installation must allow the units to operate for the duration of their designed operating horizon.

### **4 Personnel Categories**

There will be three categories of people involved with an APRS installation:

1. APRS experts – licensed amateurs who have knowledge and experience of APRS equipment and operation. One of these experts will be designated as installation coordinator for the event.
2. Licensed amateurs who have little or no APRS knowledge but who are competent to install the equipment if given adequate instructions.
3. Non-licensed persons, usually the drivers of tracker-equipped vehicles.

Installation of APRS equipment may be performed by people in either of the first two categories. Therefore adequate preparation should be made to

permit those in category 2 to perform satisfactory installations. See paragraph 6.6.

### **5 Design & Construction**

The emphasis of this document is on the installation of APRS trackers, but it must be recognised that successful tracker operation begins at the stages of design and construction. It is imperative that at least one person with actual installation experience be involved in the design and construction stages, at least as a reviewer.

A design consideration that must not be overlooked is the adequacy of power supply. Unless trackers are to be powered from the vehicle batteries, they must be equipped with self-contained batteries with adequate capacity to keep the units running at no less than 80% of full power for the entire duration of the event plus at least a 20% contingency period. The duration of the event must include any waiting period between installation of the equipment and the actual start of the event. See paragraph 12.3.

#### **5.1 Installation considerations**

The designers of the tracker must keep in mind the fact that the tracker may ultimately be installed in a vehicle that has not previously been seen, by an installer who had not previously seen the tracker. The tracker should be designed and constructed so as to be as self-contained as possible and to require a minimum of connections. There should be a trial installation of a prototype by a person not otherwise involved with the design.

### **6 Configuration & Preparation**

#### **6.1 Installation Plan**

If the operation is for a scheduled event a plan for APRS operation should either be written into the overall event plan or put into a separate document. If the APRS installation is for a real emergency then there will be no time to prepare a specific plan but a generic plan should have already been written to accommodate such situations. The experience gained from pre-planned installations will help in doing installations for emergencies.

The installation plan should cover all of the topics covered in this document. It should specify:

- Who will do the installation, when and where.
- What vehicles are to have what equipment installed

#### **6.2 Programming**

Every tracker device requires the insertion of several parameters, all of which should be specified in the APRS operation plan. These include:

- Operating frequency
- Transceiver power output

- Tactical call sign
- Symbol
- Transmission rate
- Smart beaconing parameters (if used)
- Legal call sign (in the Status Text field)
- Digipeater path

Programming should not be left to the last minute – it should be completed in time to permit testing of each unit a day or more before the event.

Nevertheless, provision should be made for last-minute changes to parameters at the event site. This means that the necessary cables, interfaces and configuration programs must be available on site.

### **6.3 Staging of Equipment**

We are all familiar with the old saying “For want of a nail, the shoe was lost.... Etc.”. The ham radio version of this idea is “For want of an adapter, a connection was lost.” Any field operation – and particularly APRS operations – will go more smoothly if a detailed list of required items is prepared in advance. “Detailed” means down to the level of individual cables and connectors. A few days before the operation the equipment should be staged, i.e. each related set of items should be set aside, checked against the equipment list and connected. In many cases different individuals may be providing different items of gear; if this is the case it may not be practical to stage all of the items at the same location but each provider should do it individually. The APRS installation coordinator for the event should maintain a master equipment list and ensure that each committed item is on it.

### **6.4 Testing**

When the equipment is staged, the next step is to test it to confirm the answers to questions such as:

- Do the GPS receivers lock on?
- Do the trackers actually transmit valid packets?
- Do the digipeaters receive and repeat packets?
- Does the APRS display computer really display and log the positions?
- What output power is each unit producing?

### **6.5 Battery Charging**

Unless power is to be supplied from vehicle batteries it is essential that self-contained tracker batteries be fully charged before the event. A top-up charge should be applied after the final testing of the units.

## **6.6 Labelling & diagrams**

Each major installation item (e.g., tracker, display, digipeater) should be accompanied by a set of installation instructions adequate to permit a Category 2 person (see paragraph 4) to perform a successful installation. Given that installations may have to be performed under adverse conditions (wind, rain, low light) these instructions should be clearly printed on a durable medium. All jacks, plugs and cables that need to be connected during installation should be clearly labelled. The instructions should include the indications that the installer should check to confirm successful installation (e.g., the LED indicating GPS lock should be on).

Tracker units that contain a mobile or handheld transceiver should have an instruction card included that tells a Category 2 installer how to:

- Unlock and lock the controls
- Change the operating frequency
- Change the output power level

Each tracker should be clearly labelled on the outside with the name of the responsible organisation and a telephone number where the organisation can be contacted during the event.

## **6.7 Rendezvous Arrangements**

It is obvious that installers cannot successfully install APRS equipment unless they know when and where to do so. The problem primarily relates to mobile tracker installations. Making the necessary arrangements is part of the pre-event planning carried out by the event organizers and the communications group. The rendezvous should be planned for a time in advance of the event start that will permit careful installation and testing of the equipment and should be at a place that will allow the parking of installer vehicles adjacent to the event vehicles.

## **7 Placement of Equipment**

Where the equipment is installed depends on the type of vehicle and on the type of equipment to be installed. The paramount consideration for any installation is the safety of the vehicle operator and its passengers.

### **7.1 Motor Vehicle**

Either a Category A or Category B tracker is usually suitable for installation in a motor vehicle such as a car, van, truck or ambulance. The choice will often depend on the estimated requirement for power output. A Category A tracker is usually placed on the floor of the vehicle, either on the passenger side of the front seat or on the floor behind the front seat. Wherever it is located it must not present a missile hazard in the event of a sudden stop. Category A trackers generally require external antennas for both the radio and the GPS receiver and both are usually on magnetic mounts, placed atop the vehicle. The cables may be either run through a partially-open window or

simply through the door jamb. I have not experienced any damage to coaxial cables from having doors closed on them.

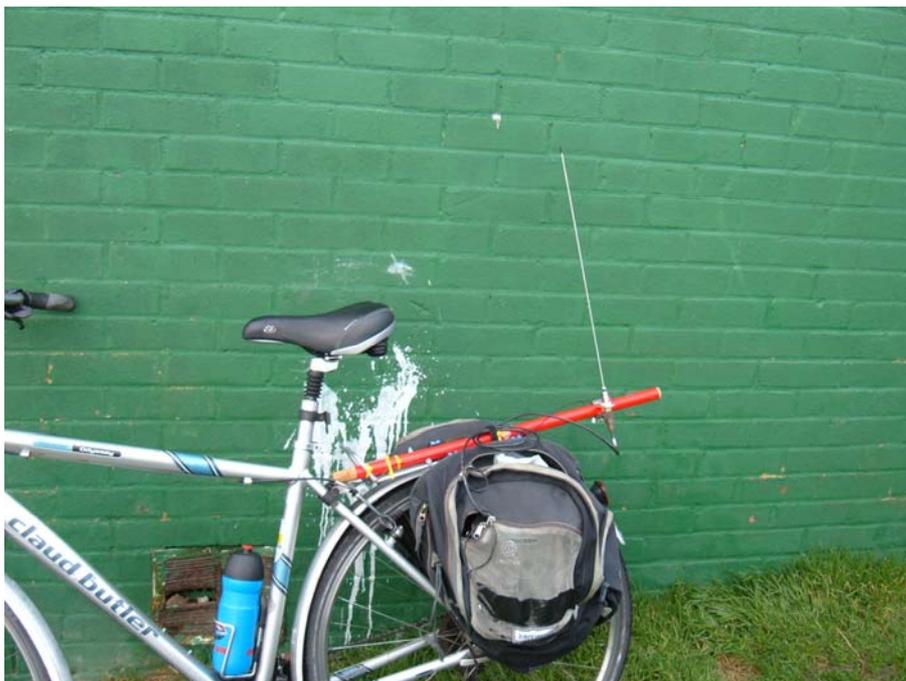
A Category B tracker may be placed anywhere in the vehicle that affords a reasonable view of the sky since it has its GPS receiver and antenna built in. I have made successful installations on the dashboard, on the rear parcel shelf and in seat pockets. Wherever it is placed, it must be secured so as not to become a missile if the vehicle stops suddenly.

### **7.2 Bicycle**

A tracker mounted on a bicycle will almost certainly be a Category B device. The placement of the tracker will depend on how the bike is equipped. If it has saddle bags/panniers the tracker can go into one, so long as the GPS signal reception is adequate. Any external battery can also go anywhere convenient, so long as an adequate length of cable is available.

If the bicycle is not available for inspection by the installer in advance of the event then some imagination and variety of hardware is necessary. The installer should come supplied with a variety of Velcro straps, cable ties, antenna mounts, etc. Devices are available for mounting mobile telephones on bicycles and these may prove useful for mounting Category B trackers, though I have not personally used them.

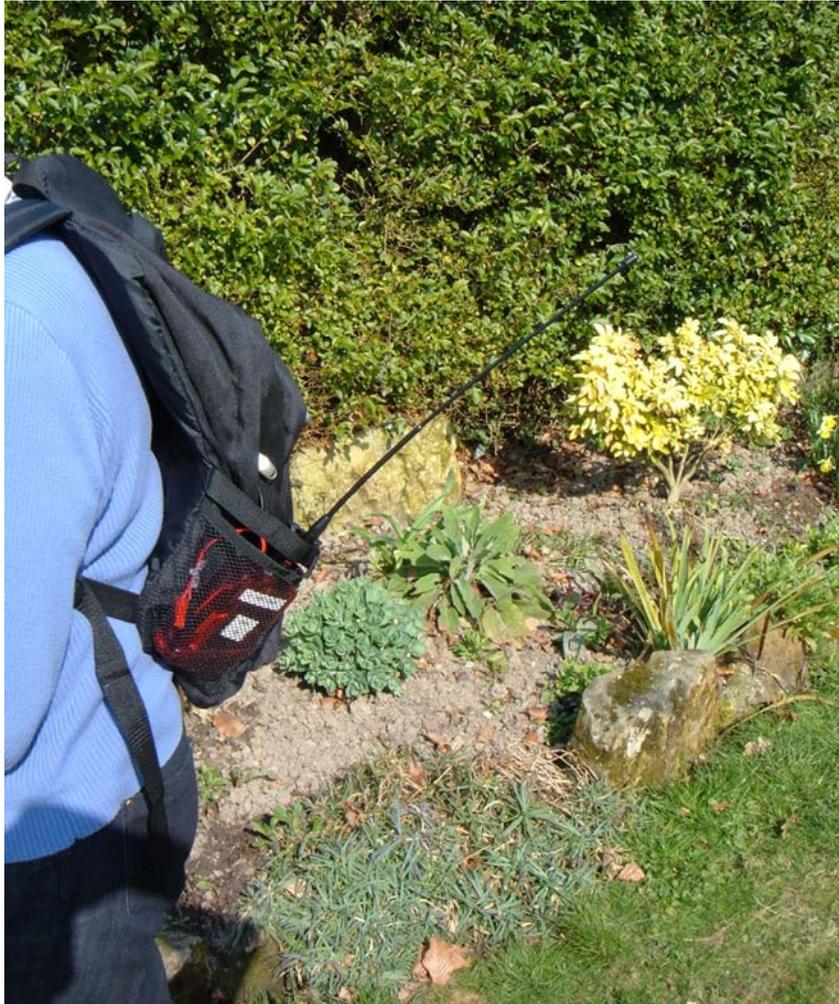
Figure 2 shows a typical bicycle installation. The tracker and its battery are in one of the panniers. The antenna is a  $\frac{1}{4} \lambda$  whip mounted on a length of dowel which is secured to the horizontal member of the frame with cable ties. The whip is attached to the dowel with an antenna mount commonly used to mount a CB antenna on the mirror frame of a truck.



**Figure 2**

### **7.3 Pedestrian**

A pedestrian (walker, jogger, or runner) will be equipped with a Category B tracker with a whip antenna directly attached. Placement of the tracker will depend on what equipment the person will be carrying. If he or she is wearing a back pack, the tracker can be placed in a side pocket of the pack or attached to one of the straps. (See Figure 3) If the person is carrying a over-the-shoulder bag, the tracker can be place in it with the antenna protruding. In either case the antenna should be kept as high and as clear of the body as possible, though usually some compromise will have to be accepted.



**Figure 3**

### **7.4 Control Station**

In contrast to a tracker, which is a transmit-only device, the APRS equipment at the control station will usually be set up to only receive and log position reports. And since it will probably not be moving, there is no need for it to have a GPS input. Thus it will consist only of a radio (which need only be a receiver unless object or message transmission is planned), a TNC and a computer with the appropriate software. It will need an antenna with adequate gain, mounted as high as possible, so as to capture the signals from the trackers, which may be running low power to marginal antennas.

Beyond these generalizations it is difficult to describe a typical control station. How and where it will be installed depends on what use is to be made of the tracker information and by whom. The most basic form of control station will be limited to displaying information on the screen of the station computer (which will usually be a laptop). The information will be more easily used by event managers if it can be presented in a larger format; the use of a computer projector to project the display onto a suitable screen or wall has been successfully employed in past events.

### **7.5 Digipeater**

Depending on the geographic extent of the event, digipeaters may be needed to ensure reliable coverage. Digipeaters will have something in common with trackers, except that, being stationary, they do not require GPS input and they will usually have better antennas than mobile units. The main installation considerations are ruggedness and security. In many instances digipeaters will be installed in locations where no one – licensed amateur or event staff – will be in attendance. If this is the case, the digipeater must be installed so as to attract the least possible attention from thieves, vandals or other undesirables.

## **8 Radio Antenna Mounting**

### **8.1 Mag Mount**

The magnetic mount is the most common form of temporary mobile antenna installation. These come in various sizes and it is best to avoid the smallest ones which have less holding power, particularly if something longer than a  $\frac{1}{4} \lambda$  VHF whip is to be mounted. Mag mounts generally have a rubber membrane to protect the vehicle surface but despite this some owners may be reluctant to have them placed on their roofs. It may be advisable to have a supply of plastic sheeting available to provide additional protection of the paintwork and thereby reduce the objections.

Some ambulances have non-metallic bodies and consequently mag-mounts are not suitable for use with them. If ambulances are among the vehicles to be equipped with trackers it is advisable to inspect them in advance of the event to ascertain their construction and to devise alternative mountings if mag-mounts are not usable. If advance inspection is not possible, then the installers must come to the event with a variety of mounting methods (e.g., drip moulding mounts, mirror bracket mounts). Even if the body of the ambulance will not support a mag-mount, it is possible that the cover of the engine compartment may be steel. If all else fails, then it may be necessary to resort to duct tape.

### **8.2 Roof Rack**

If an event vehicle will be equipped with a roof rack it may be possible to use it to mount an antenna. Special mounts are available for the purpose.

## **9 GPS Antennas**

Most GPS antennas are of the “hockey puck” variety and have built-in mounting magnets. The comments in paragraph 8.1 apply.

### **10 Power**

#### **10.1 CAUTION**

The majority of vehicles in which trackers will be installed will have 12 volt power supplies, but in a few cases the voltage may be different. Some very large trucks (which may be used to haul floats in parades) may have 24 volt supplies and some vintage vehicles may have 6 volt supplies. Before connecting to the vehicle power supply (as described in paragraphs 10.3 and 10.4) use a voltmeter to verify the voltage.

#### **10.2 Dedicated battery**

The preferred method of providing power to a tracker is with a dedicated battery, and for bicycle or pedestrian trackers it is the only method. Category A trackers usually have room in the box for a battery and Category B trackers may also accommodate an internal battery if the event duration and transmit power requirements are modest. For a lengthy event it may be necessary to have replacement batteries available. Of course all batteries must be fully charged in advance of the event.

#### **10.3 Vehicle battery**

If the tracker is installed in a motor vehicle an alternative source of power is the vehicle battery. The connection should be made with crocodile clips or ring connectors attached directly to the battery posts and enough cable, of adequate size, must be provided to accommodate connection between a battery in the engine compartment and the tracker in any possible location within the vehicle. As with coax, no harm will usually be done to cable if doors are closed on it. All such cables must be equipped with fuses located at the battery end of the cable.

#### **10.4 Cigarette lighter**

The least satisfactory source of power is from the vehicle battery via a cigarette lighter receptacle. Not only are these connectors sometimes unreliable and of limited current-carrying capacity, but they also suffer from the disadvantage of being turned off along with the vehicle ignition. They should be used only as a last resort.

#### **10.5 Fuses**

All units must be adequately protected by fuses. This is especially important if a unit is to be powered from the vehicle battery. All units should have spare fuses provided.

### **11 Relations with Vehicle Owners/Drivers**

Vehicle owners and drivers are usually quite cooperative in allowing the installation of APRS units in their vehicles but occasionally there is some

reluctance, especially if the vehicle is an expensive late model. Even if the event organisers have agreed that the vehicle should be equipped with a tracker this does not grant the emergency comms group the right to make an installation in a privately owned vehicle. If the owner is reluctant to allow the installation the only tools available to the installer are the arts of negotiation and persuasion. Obvious reference to the protective measures mentioned previously (e.g., plastic sheeting, fuses) may help. In the face of a total refusal the installer can only refer the situation to the installation coordinator who will in turn report it to the event organiser.

### **12 Completion of Installation**

When the physical installation is complete the installer should verify that the unit is working properly. The installation instructions should include a checklist giving the values and indications expected.

#### **12.1 Checkout**

- *GPS lock* – Some GPS units indicate satellite acquisition by showing a flashing LED, others by a steady light. The instructions should indicate which to look for. The installation is not complete until the installer can verify that the unit is locked on.
- *Power output* – if available, a small in-line wattmeter should be inserted between the radio RF output connector and the antenna to verify that the unit is producing its rated power.
- *Battery voltage* – a voltmeter or power analyzer should be used to verify that the battery is providing its rated voltage with the unit operating.
- *Reception by control* – the operator of the control station (where position reports are being displayed) should be asked to confirm that reports are being received from the station

#### **12.2 Notification to Net Control**

When the installation, including the checks described in paragraph 12.1, has been completed, Net Control should be notified. Since installation may be carried out at some distance from the Net Control station, it will be useful if installers have hand-held radios operating on the NCS frequency.

#### **12.3 Continuity of Operation**

Installation should be scheduled to allow adequate time before the commencement of the event to permit the installation checks. Once correct installation is confirmed it is preferable that the equipment not be turned off. Experience has shown that problems can arise in powering down the equipment and then turning it back on just before the start of the event. Obviously operation between installation and the start of the event will drain charge from a dedicated battery. This makes it necessary to plan installation scheduling (not too far in advance of start) and to provide adequate capacity to cover the waiting period.

### **13 Emergency Shutdown**

Emergency shutdown of a malfunctioning unit will usually be performed by disconnecting the power supply. This will normally be done by the Category 1 or 2 person who has the quickest access to the unit. While there is no reason that a Category 3 person (e.g., the vehicle operator) could not perform a shutdown, there will not usually be voice communication with the vehicle by which the instructions can be given.

A card with emergency shutdown instructions should be given to each Category 2 person assigned to an event checkpoint, including those who have no other involvement with the APRS aspects of the event.

### **14 Recovery of Equipment and Data**

The final step in any APRS operation is to recover all the equipment. Vehicles with trackers must have been instructed to return to the assembly point. Someone from the emergency communications group will be assigned to collect any digipeaters from unmanned locations and those at event checkpoints should be returned by the operators at those checkpoints. The recovery plan must be agreed with the event organisers in advance of the event.

Before the station control computer is turned off the installation coordinator should ensure that the logging function is properly shut down and that a backup copy of the log is written to an external medium.

### **15 Review of the Operation**

After the event has been completed, and with as little delay as possible, an after-action report should be written by the installation coordinator. This report should include input from installers, net controllers, vehicle operators and event managers. The main objective of this report is to record lessons learned during the event, for use in future events. The log data recorded on the station control computer is a valuable source of information for the report.