The Cavedale Road Emergency Resource Project

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This document is a work in progress and provides highlights of the project. Currently it is entirely volunteer driven, and like a Kickstarter campaign, there is no guarantee that it will achieve its objectives in a timely manner.

Just imagine: you live on Upper Cavedale Road, and PG&E shut down the power three days ago. Your WiFi is out, your cell phone battery is dead and you can see smoke approaching from Napa and the Oakville Grade. Due to the ongoing strong windstorm, a tree falls across your entrance and you are trapped, as helicopters circle above. Wouldn't you like to have a battery powered digital communicator, where you could press one button to ask for help to be dispatched?

We can make this happen. And much more.

Problem statement: In a worst-case scenario, local residents cannot be notified to prepare for imminent evacuation and, when it is time to evacuate, be told whether to evacuate up or down Cavedale Road to safety. Worst case situations can arise should there be a multi-day PG&E "PSPS" or other loss of electricity. Cell phone batteries can be flat after 24 hours, and cell towers might be destroyed or lose their battery power. Landlines which rely on VoIP will be out. Cavedale Road may have closures which prevent the Sheriff from directly informing residents of the situation. And so on. Just imagine the worst scenario you can; this network is designed to function despite it all.

Note: while this project was inspired by personal experience with the Nuns Fire of October 2017, the capabilities described below would be valuable in anticipation of other disasters, e.g. earthquakes, floods, tornadoes, tsunamis, terrorist or even zombie attacks!

The proposed solution: Design and implement a robust low-cost digital communications network which is independent of any other devices and networks, and that will operate autonomously on batteries for at least 2 weeks. Include a color touch screen for displaying notifications and entering messaging input, and a really loud and annoying alarm for critical notices.

Design elements: There are two types of units, as shown in Figure 1 and 2 below. Other form factors could be developed in the future.

The home console has a very low power long range digital radio unit ("LoRa") and a color touch screen for message display and input, an audible alarm, four push buttons and WiFi capability. The unit's internal battery is powered by a standard USB-C charger when electricity is available in the home. Home consoles optionally connect to the local WiFi, used to remotely update the system software "OTA" (over the air). When the power is out, WiFi is disabled along with enabling other power saving measures. The internal battery has a measured lifetime of over two weeks once the USB power dies. (Connecting an external battery could further extend the time if desired.)

The second unit type of unit is an outdoor waterproof PVC pole-mounted repeater. It has only the radio section, and the internal battery is kept charged via 10W solar power. Even with complete lack of sunlight, the internal battery is sufficient for over two weeks of operation. Remotely triggering a repeater reboot while hovering a tiny SSH Server via a drone will update its software (Figure 3). Alternatively, a technician physically can go near the unit, reset it via a magnetic switch, which will then connect to a nearby handheld computer and download the latest software version. As of May 2024, a high speed update path between adjacent repeaters is being deployed and tested.

The digital radios easily have a 1/2 to 1 mile range but require a reasonably clear line of sight between each other. Each repeater unit receives data from other units and forwards it onwards to the destination along the entire length of Cavedale Road, using the pole-mounted repeaters as relays. The system is entirely self-configuring, forming a highly robust mesh network.

From one or more "authorized" home-type consoles or remotely through the enabled WiFi connection, commands can be sent either directed to one specific station or broadcast to all stations. Alert messages can be broadcast to every station with a single command. Other messages include "Are you OK?", which asks a home user to reply by pressing either an "I'm OK" or "Send help" button. Messages can be quietly displayed, or displayed with an alarm that resets after several seconds, or with an alarm that must be acknowledged and reset via a button push. Messages are typically canned texts, e.g., "Prepare for imminent evacuation", although there is a capability for sending a custom typed-in message to a specified unit or to all stations. The system is not intended to be used as an alternative to SMS text messaging, even though many of those capabilities are present. On the console's main screen there is a prominent button labeled "I need help" which will send an audible alert message to other authorized stations.

There are system management commands which report on the connectivity of the relay network, enable and disable repeaters, change power levels, reboot stations, and collect data on a variety of operational items, such as battery levels, received signal strengths, etc. Important status messages such as the loss of AC power on a home unit or an imminent battery brownout are broadcast to all administrators.

The entire design, hardware and software, will eventually be "open sourced" and available free of charge to anyone who wishes to clone it and, hopefully, add improvements.

Unit construction costs: The parts cost appears to be about $150 for the home console and $100 for the pole-mounted repeater, including circuit boards, cases, batteries, etc. An initial batch of 40 units are currently being assembled by a third party vendor, and if built in "large" quantities costs might significantly drop.

Full deployment cost: It would be attractive to find sufficient funding (via donations or grants) to fully deploy the "backbone", e.g., the set of relay stations running seven miles from Hwy 12 up to Trinity Road. With the backbone in place, individual homeowners might have the option of "buying in" to the project by purchasing individual consoles. Iterating towards a working and robust network will indicate how many repeaters might be appropriate. My gut feeling is at most 20 repeater units are needed; a grant of $10,000 could suffice to fully deploy this infrastructure for both Cavedale and Trinity Roads.

Communications hierarchy: The system supports station-to-station messaging as well as broadcast message. Messages can be designated as "for admins only" so home owners aren't bothered by management messages about things like low battery voltages, system reboots, etc. In addition, messages can be sent to a specific group ("multicasting"). On Cavedale, our "PODS" Firesafe Leaders, can have one group for their internal communications, and there can be a group for each of the PODS themselves, for a leader to communicate with their nearby neighbors. Other groups can be created to handle specific types of issues that should not be brought to the attention of everyone, even all admins.

Readiness drills: Like any other emergency system, it will work during an actual emergency only if people are trained and confident using the system in advance. Having a semi-annual simulated disaster could ensure that everyone is ready in case "the big one" comes.

Participation: It would be extremely valuable to secure the cooperation of the local Fire Department, CalFire and the Sheriff in addition to local homeowners. Neighborhood volunteers who are part of a "CERT" (Community Emergency Response Team) or local "PODS" would liaise with the first responders, and under their direction, be the ones to send out messages such as "Evacuate now!" to homeowners. Putting in place clear guidelines about communication and notification authorization needs to be put in place and revised from time to time.

Known limitations and issues:

1. The outdoor pole mounted units are weather resistant but not fireproof. (The units have a built-in temperature sensor and sends out an alert if they start cooking, prior to melting.). In a disaster, part of the network may go down. However, robustness can instead be achieved by overbuilding the outdoor relay network, which is very inexpensive.
2. Cooperation of homeowners is essential to being able to site the outdoor repeaters on a long-term basis, as well as during deployment phase experiments. Theft of units may be a serious concern; but see #5 below.
3. While the project is not excessively costly, funding will be needed to acquire parts and build the requisite number of units. Sources could include homeowners, the MVFF, County TIF funds and PG&E or other philanthropic grants.
4. Should PG&E be interested in supporting this project, their right of way and installed power pole infrastructure might be extremely helpful to site the repeaters.
5. Normally there is very little radio traffic, basically only some maintenance information being sent around. During an emergency, this could change dramatically. It needs to be field tested in advance to make sure it performs correctly. It also may push the FCC utilization limits on the single radio channel used by this design, but that seems reasonable when lives are at stake.
6. The network can address a maximum of 255 stations, which should suffice for our community. Additional independent networks may co-exist, and the design allows, in principle, for the construction of interconnection routers.

Project status: The software is "95%" complete. (Experienced software engineers will know how to interpret that estimate!) Using the OTA update procedure additional features or tweaks can be deployed remotely.

There are five or more fully operational prototypes of the home console, with 25 more under construction. Eleven units of the outdoor pole mounted repeater have been built and deployed as of May 2024. By judiciously placing them on the top of ridges and knolls, despite the canyon-like nature of Cavedale Road, the system easily covers a region about 4 miles long and 1 mile wide with excellent signal strength and with a high robust overbuilt mesh. Consoles can easily send and receive data inside frame structures without requiring special placement nor especially nearby repeaters. (See Figure 4)

Next milestones:

1. Continuing the iterative process of building additional repeaters and finding sufficient cooperative homeowners to cover Hooker Creek, from Highway 12 up to Trinity Road.
2. Approaching potentially interested sponsors with a robust demo.
3. Engaging our CERT, CalFire, the Sheriff and other parties to understand their interest in participating during an actual emergency.

Operational Deployment: Hopefully the system can be largely deployed and operational prior to the 2024 fire season. Other than having a sufficiently robust backbone, there is no need for any specific number of homeowners to participate. However, the larger the number, the more robust the network will be.

Figure 1. A home console unit

Figure 2. An outdoor solar powered repeater unit

Figure 3. Aerial 17 gram SSH Server

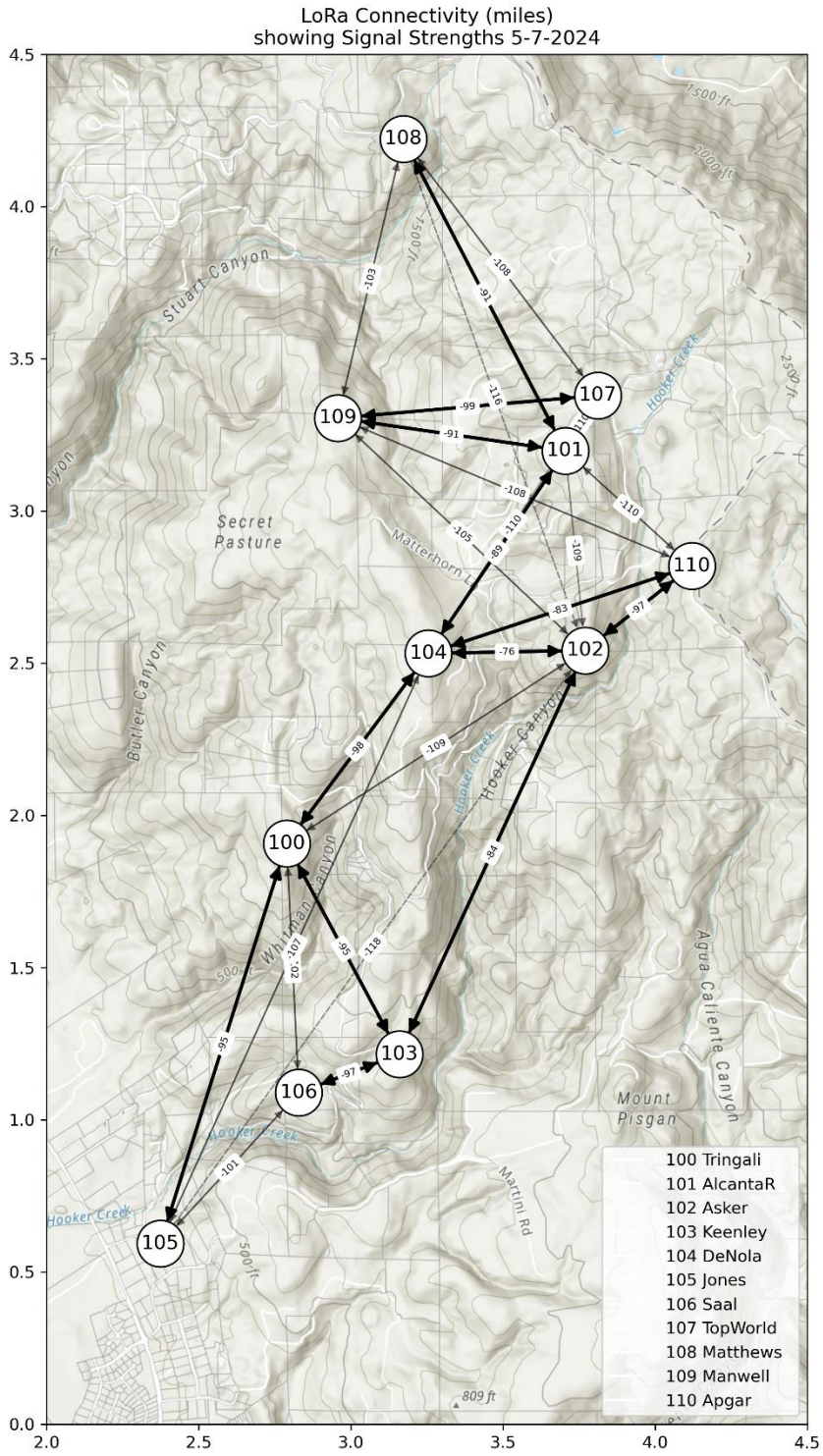

Figure 4. Cavedale Road Topo and Coverage