

# VAROOM – Volcanic Application of Real-Time, Onsite, Optical Monitoring

Final Report for the Period 9/1/00 – 9/1/01  
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## ***Abstract***

A solar-powered camera system was designed and is currently being assembled at the University of Iowa. The system is targeted for deployment as part of the suite of tools used by the Volcanic Disaster Assistance Program (VDAP) of the United States Geological Survey (the “Survey”). The camera will be mounted in a remote location near a hazardous volcano under study. The system’s digital transceiver will send digital images of the volcano up to 10 miles away at rates up to 1 image every 15 minutes, in normal operation. The principle design characteristics of the system are to use less than 100mA, an amount determined to be practical with solar powered instruments used by the Survey in previous applications, be resistant to lightning strikes common around active volcanoes, transmit information to receivers up to 10 miles away, be lightweight and capable of being transported in a commercial aircraft, and to operate for long periods without maintenance. The system has been designed and is currently being assembled at the University of Iowa’s GROK Laboratory. The VDAP program has provided substantial assistance (primarily advice) to the project and looks forwards to experimenting with the system after its testing phase. The costs of the system were substantially reduced as a consequence of the Survey’s concerns.

## ***Introduction***

The Volcanic Disaster Assistance Program (VDAP) of the United States Geological Survey is an international leader in volcanic observation and eruption prediction. VDAP member scientists are frequently invited to study active volcanoes abroad to advise local scientists regarding the scale and timeline of likely future eruptions.

Often VDAP scientists travel with an array of equipment including seismometers, tilt meters, gas monitors, and surveying instruments. After arriving at the site of an active volcano, they set up a local base. The location of the base often depends on the accessibility of local infrastructure, such as communication equipment, roads, helicopter

landing sites, and the location of other scientists and interested parties. It is not unusual for this location to be many miles from the site of the active volcano. In order to make direct observations of the volcano, the scientists often must rent or borrow a helicopter and fly to the volcano's location. Weather and volcanic activity often make flying conditions too hazardous to be attempted – often this is known only when the helicopter has flown within visual site of the volcano. Because of the cost of renting the helicopters, a remote visual observation is of great interest to the geologists in the VDAP team.

Previous remote camera systems have failed for a number of reasons, but primarily because the systems require either a connection to a live power grid, which is rare in the areas near an active volcano, or because consume too much power from their solar systems to be reliable. Installing a device near a volcano is a dangerous, time consuming process. It often involves either landing a helicopter or driving many miles through steep terrain on poorly maintained roads. In some cases it may even mean hiking to the remote spot. If a device requires frequent maintenance, the geologists are unlikely to wish to extend the effort to even place the instrument initially. Consequently, ease of installation and use, reliability and low power consumption are primary concerns in the design of the VAROOM system.

### ***Purpose***

The purpose of this project is to design, implement and test a remote camera system capable of meeting the needs of the VDAP program so that it will be part of the instrumentation suite that they typically deploy when investigating a new volcano.

### ***System Description***

The system is designed around a commercial camera, the FujiFilm MX-1200, which provides 1,280 x 960 pixel resolution with 24bit color, with jpeg compression. The camera was selected because of its low cost and its capability to transmit high-resolution images over a serial connection. Most digital cameras depend on either parallel connections, which would be difficult to transmit, or are designed for fast frame-rate and low resolution. The camera has been reverse-engineered so that the power switch, mode selection and shutter control can be controlled electronically.

A StampII processor from Parallax Inc. will form the administrative heart of the system. This low power processor will control all the signals within the system. The processor, which operates at 10000 operations per second, will monitor the power level, monitor and report the status of the components, and periodically turn on the transceiver to listen for incoming messages. At appropriate intervals, the microprocessor will power the camera and transceiver and send a signal to the camera to collect and image, and ensure that the image is correctly transmitted.

The transceiver is a WIT2410 model from Digital Wireless. This 2.4 GHz transceiver uses a spread spectrum, which will simplify its operation in an environment in which the local uses of radio transmitters are not easily predicted in advance. If the local military uses one particular band within the available spectrum, for example, the transmitter will automatically transmit on other frequencies.

The power system relies on a Siemens 36W solar cell. The power from this cell is delivered to both the sealed gel fuel cell (Deka Dominator) and the system circuit. The transfer of power and charge of the battery are carefully monitored and controlled by the Trace C12 solar charge controller. The fuel cell was selected for its ability to repeatedly suffer deep discharges without limiting the operational life of the system, as would a standard car battery. Although a lead acid battery would be more efficient, such batteries may not be transported on airplanes, whereas a sealed gel cell, which are nearly as efficient, are FAA approved.

Since beginning the work, a number of redesigns have been necessary. The first change was to remove a digital thermographic camera. This design, which would have provided unprecedented temperature measurements in the volcanic crater, was eliminated because the VDAP team suggested that no equipment would be mounted near enough to the crater to collect such images, and that the \$5000 cost of the imager was too great at this early stage.

The next design challenge came when the VDAP team felt that a \$10,000 was far too expensive for its use, particularly in comparison with the other equipment in its traveling arsenal. We have since scaled back the transmitter and camera requirements so that the current system contains approximately \$3,000 in parts, which is dominated by the \$1750 for the transmitter pair.

### ***Current Status***

The each component of the system has been tested and is operating independently. As of February 26, 1991 the system is being integrated on breadboards. After several schedule setbacks early in the project, we look forward to finishing a system mock-up by March 30 and begin testing by April 1. After the final system has been tested in the field for six months, broadcasting directly to the World Wide Web, we will work with VDAP to get a system fielded to an active volcano.

### ***Future Work***

The utility of a robust camera system leads to a number of possible follow-on projects. We have spoken with Thomas Schnell about using the camera for remote roadway monitoring, for example. For this application we would require live video streaming capability. We would also like to reintroduce the possibility of thermographic monitoring to the VDAP team, once they are convinced of the system's usefulness. Finally, we would like to investigate the possibilities of using a narrow field-of-view optical system and a pan and tilt gimble in order to get higher resolution images of specific features on the mountain.

### ***Conclusions***

The current design indicates that a remote monitoring system is both feasible and potentially useful. The interaction with the VDAP team has led to a number of significant design changes, but we are optimistic that the system is much more likely to be useful in the field than it would have been without the advice from the experienced geologists. The current power requirements meet the 100mA threshold and the cost is down to \$3,000 – both factors are within the necessary region for practical volcanic monitoring.