

## Chapter 12

# Remote Telemetered and Time-Lapse Cameras at Augustine Volcano

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### Abstract

Before and during the 2006 eruption of Augustine Volcano, the Alaska Volcano Observatory (AVO) installed a network of telemetered and nontelemetered cameras in Homer, Alaska, and on Augustine Island. On December 1, 2005, a network camera was installed at the Homer Field Station, a University of Alaska Fairbanks Geophysical Institute (UAF/GI) facility on a bluff near Homer, where telemetered Augustine data are received. The camera placed there provides observations of the volcano from a distance of 126 km (78 miles) in daylight hours during clear sky conditions. On January 9, 2006, a radio-telemetered network camera was installed on the lower eastern flank of the volcano at "Mound," 4.4 km (2.7 miles) from the summit. The proximity of this camera provided for near-field images of the volcano. A nontelemetered camera with onsite recording was installed 3.8 km (2.4 miles) north of the volcano's summit near Burr Point on December 17, 2005. This camera recorded high-resolution images at a rate of 4 images per hour through much of the eruptive sequence. A low-light camera was installed on February 8, 2006, at the Homer facility to augment the extreme low-light camera installed by the UAF/GI (Sentman and others, this volume). On September 10, 2006, a second radio-telemetered network camera was installed at Lagoon camp on the west side of Augustine Island, 5.4 km (3.3 miles) west-northwest of the summit. The installation of these camera systems proved valuable for assessing volcanic activity, determining ground hazards and on-island weather for visiting field teams, and deciphering depositional history after the eruption.

### Introduction

Augustine Volcano, in lower Cook Inlet, is one of the most frequently active volcanoes in Alaska, recently erupting in 1976 and 1986 (Miller and others, 1998). Increased seismicity and deformation, starting in April 2005 and escalating in November 2005, indicated that the volcano was likely to become active once again (Power and others, 2006). Therefore, the Alaska Volcano Observatory (AVO) installed a network of telemetered and nontelemetered cameras in Homer, Alaska, and on Augustine Volcano (fig. 1) in anticipation of an eruption. These cameras, similar to ones previously installed by AVO to monitor Veniaminof and Spurr volcanoes, augmented telemetered geophysical data and provided frequent visual observations of this remote volcano. Images from the telemetered cameras were served over the Internet on AVO's Web site for internal and public use. This paper presents a description of the equipment and installation of these cameras, and a chronology of when they were operational. More detailed analysis of the images is presented in Coombs and others (this volume) and Vallance and others (this volume).

### Chronology of the 2006 Eruption and Camera Installation

Beginning in mid-2005, AVO detected an increased number of earthquakes beneath Augustine's summit and evidence of inflation of the volcanic edifice (Power and others, 2006). Seismicity increased to higher levels in November 2005. Several phreatic explosions occurred in December 2005. On January 10, 2006, seismicity increased sharply, and this was followed on January 11 by two brief explosive eruptions. From January 13 through 28, 11 more discrete vulcanian blasts produced ash clouds that rose to 16 km above sea level (asl), pyroclastic flows, lahars, and avalanches on the island

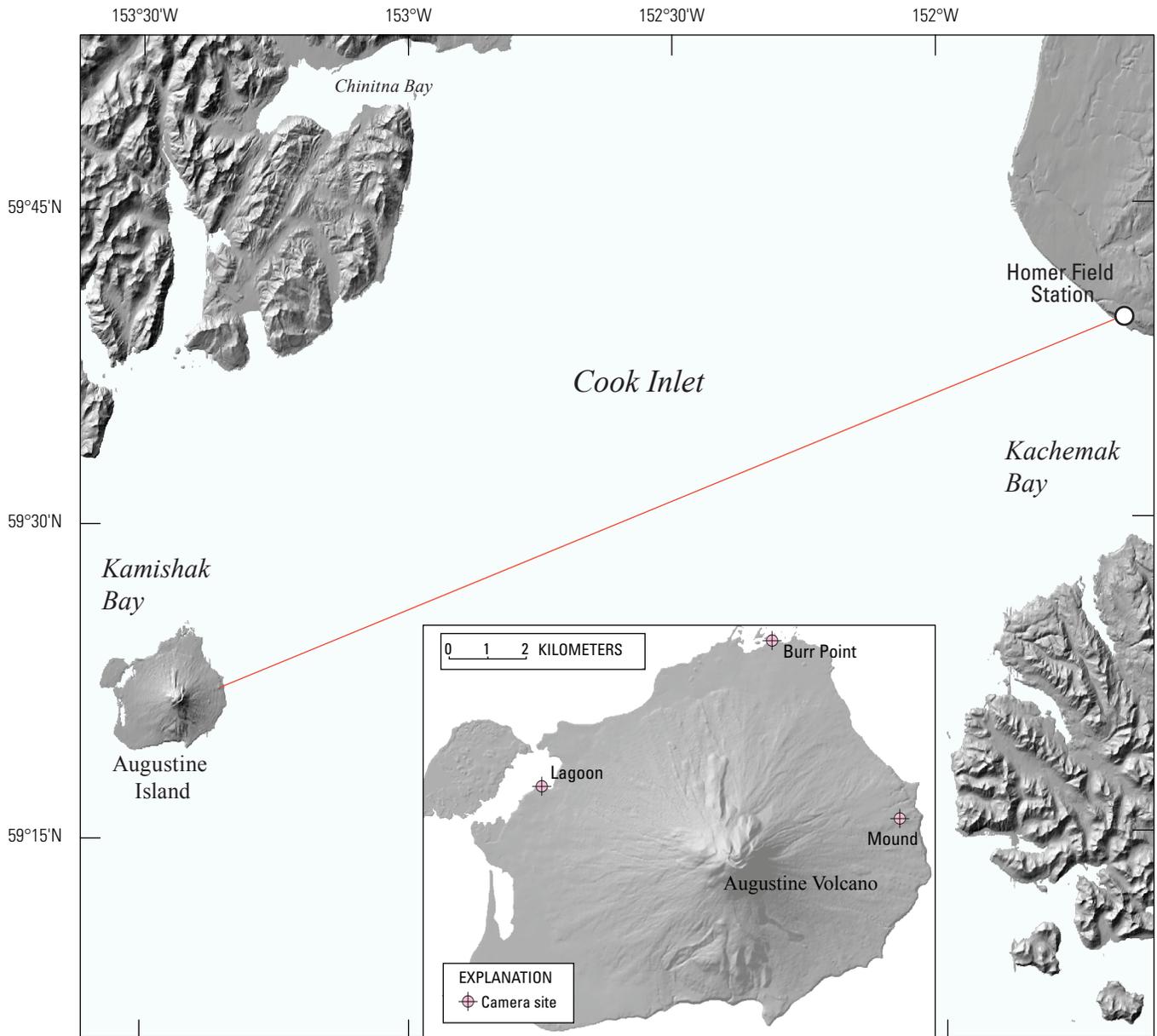
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(the “explosive phase”). On January 28, the volcano entered a period of more continuous activity consisting of rapid lava effusion, block-and-ash flows, and ash emission (the “continuous phase”; Coombs and others, this volume). After a pause in activity from February 10 to March 3, activity resumed during the “effusive phase” as two lava flows and a new summit lava dome were emplaced, accompanied by many small block-and-ash flows from the growing lava bodies.

A network camera was installed at the Homer Field Station on December 1, 2005. A nontelemetered camera with onsite storage was installed on the north flank of the volcano near Burr Point on December 17, 2005. On January 9, 2006,

AVO installed the first remote radio-telemetered network camera on Augustine Island east-northeast of the summit at a site informally known as “Mound,” just two days before the onset of the explosive phase. On February 8, 2006, a low-light camera and network video server were installed at the Homer Field Station. The final network camera was installed on the west side of Augustine Island at the informally named “North-west Lagoon” on September 10, 2006. Daytime activity during all three phases of the eruption was mostly imaged by both the netcam at Mound and the nontelemetered camera at Burr Point, except when weather clouds or ash obscured the view. The image records of both the telemetered and non telemetered



**Figure 1.** Map of lower Cook Inlet showing Augustine Island and telemetry path (in red) from the Mound camera back to the Homer Field Station. Inset map shows location of cameras on Augustine Island.

telemetered cameras were occasionally interrupted during parts of January and February as a result of various power problems, exceeding on-site recording capacity, and physical damage to the installations. Cameras located in Homer did not image any of the explosive activity because of poor visibility, but they did record much of the activity during the continuous and effusive phases of the eruption.

## Cameras Used

A variety of cameras were used to establish the visual monitoring network (table 1). Stardot network cameras were used for telemetered daylight images. The Stardot Netcam MegaPixel is an IP networked camera (appendix 1). Its Web interface allows adjustment and control of various parameters, including those affecting image quality, date and time stamps, text overlays, security, file naming, and image transfer. Near-real-time images can be viewed remotely using http and automatically uploaded to designated servers using ftp.

A Watec 120N analog camera connected through a Stardot video server provided telemetered nighttime images. The Watec 120N is a monochrome low-light camera with sensitivity in the near-infrared (appendix 1). It was used in conjunction with a Watec 120N control box which allows for gain adjustment and image integration. Images from this camera were sampled and transmitted across a Stardot Ethernet-based video server (appendix 1).

A Nikon COOLPIX 8700 configured with a Harbortronics DigiSnap 2000 time-lapse control system was used to take time-lapse images and store them on-site. The Nikon

COOLPIX 8700 is an 8 effective megapixel digital camera. The Harbortronics DigiSnap 2000 controls image sampling intervals, and a Harbortronics voltage regulator conditions the power needed by both the camera and DigiSnap 2000. This system was tested, packaged, and provided by the Hawaiian Volcano Observatory (HVO) and is further described in Orr and Hoblitt (2008). Vendor specifications for equipment used in this package are given in appendix 1.

## Homer-based Network Camera

A Stardot Netcam MegaPixel camera was installed at the UAF/GI Homer facility on December 1, 2005. It is mounted on a window ledge inside the facility and aimed through a window at Augustine Island. The camera is fixed with a remotely controllable 8 mm to 48 mm motorized zoom lens. It is attached to the Homer-based UAF/GI network and is accessible through the Internet. It sends images at user-defined intervals to an ftp server at AVO facilities in Anchorage. Images were transferred at 5-minute intervals throughout the eruption.

The distance of this camera from the volcano (126 km, or 78 miles) allows for a broader field of view, useful for determining heights and lateral trends of plumes. However, darkness and cloud conditions between camera and target often prevented observation of the volcano, and none of the explosive events in January were imaged. This camera did provide useful images during the continuous and effusive phases of activity at times when clear skies coincided with daylight hours (fig. 2). More proximal cameras that require radio telemetry or onsite storage were decided upon to capture the potential eruptive activity.



## Mound Network Camera

A radio-telemetered Stardot Netcam MegaPixel camera was installed at Augustine Volcano at “Mound” on January 9, 2006, just before the onset of explosive activity. Mound is located on a small hill on the east side of the island at an elevation of about 100 m and 4.4 km from the summit. The camera is mounted within a Stardot enclosure attached to a solar panel mounting structure (fig. 3).

The equipment package (fig. 4) at Mound includes a Trimble NetRS GPS receiver for deformation monitoring, a RefTek ANSS-130 strong-motion accelerometer for seismic monitoring, the Stardot

**Figure 2.** Image of Augustine Volcano, 78 miles away, captured by the Homer Field Station netcam on December 1, 2005.

**Table 1.** Summary of cameras installed during 2005 and 2006 to monitor Augustine Volcano.

Camera Name	Camera Used	Date of Initial Deployment	Lens Used	Operating Resolution (pixels)	Image Capture Frequency	Camera Outage/ Reduced Capture Rate
Homer Netcam	Stardot Netcam Megapixel	12/1/2005	8-48-mm motorized zoom lens	640×480	1 image every 5 minutes	None
Homer Low-Light Camera	Watec 120N	2/8/2006	n/a	758×494	1 image every 2 minutes	None
Mound Netcam	Stardot Netcam Megapixel	1/9/2006	8-mm zoom lens	640×480	2 images every 30 minutes	1/17/2006 – 2/21/2006: Frequency of image capture reduced during low visibility or darkness to save power.
Burr Point Time-Lapse Camera	Nikon COOLPIX 8700	12/17/2005	Built in Nikon lens	1,024×768 (in TV mode)	1 image every 15 minutes	1/23/06 – 2/24/06: Camera was removed from island for maintenance. 5/13/06: Camera ran out of battery.
Lagoon Netcam	Stardot Netcam	9/10/2006	8-mm zoom lens	320×240	2 images every 60 minutes	Occasional outages due to poor radio telemetry.

camera system, a serial-based power controller, a serial-to-Ethernet device server, and an Intuicom EB-1 wireless Ethernet bridge. All Ethernet devices are part of the Homer-based UAF/GI network and are linked to it using the Intuicom Ethernet Bridge (appendix 1).

The image interval of this camera was decided partly by bandwidth limitations, but mostly by power considerations. The combined power requirement of the equipment at Mound is nearly 12W, which is a heavy load for a small-scale solar power system during the winter months in Alaska. Power use had to be managed to stay within the limits of the reserve and recharge rate of the power system, which was done through a USGS-designed power controller (appendix 2). This is a device that reports site voltage and allows management of four independently controlled power ports through a terminal session. The camera was placed on a power port that is programmable for powering on at user-defined intervals and durations. The Mound camera was typically set to power on at 30-minute intervals for 5-minute durations. The camera was powered on for longer durations during periods of anticipated or actual eruptions. While powered on, the camera was set to transfer images at 2-minute intervals.

One of the advantages of a near-field camera is that it suffers far less obstruction from cloud and fog than a camera (in this comparison) placed 78 miles away in Homer. While the Homer camera failed to image any of January's explosive events, the Mound camera imaged most of them. The most impressive sequence imaged by the Mound camera was during

an explosive event on January 13, between 16:35 and 16:45 AKST (fig. 5).

## Low-light Camera

A Watec 120N low-light camera was installed at the UAF/GI Homer facility on February 8, 2006, which supplemented a small astronomical CCD camera (Sentman and others, this volume). The low light camera is mounted on a ledge inside the facility and aimed through a window at Augustine Volcano. It is attached to the Homer-based UAF/GI network by a video server. The video server is accessible through the Internet and sends images at user-defined intervals to an ftp server at AVO facilities in Anchorage. Images were transferred at 2-minute intervals through most of the eruption.

This camera allowed viewing of the volcano at night. It imaged much of the summit area activity during the effusive phase of the eruption (fig. 6).

## Time-Lapse Camera

A stand-alone 8.0 megapixel Nikon COOLPIX 8700 digital camera system was installed on an old debris-flow deposit on the north side of the volcano at Burr Point on December 17, 2005. The camera enclosure housed the camera,



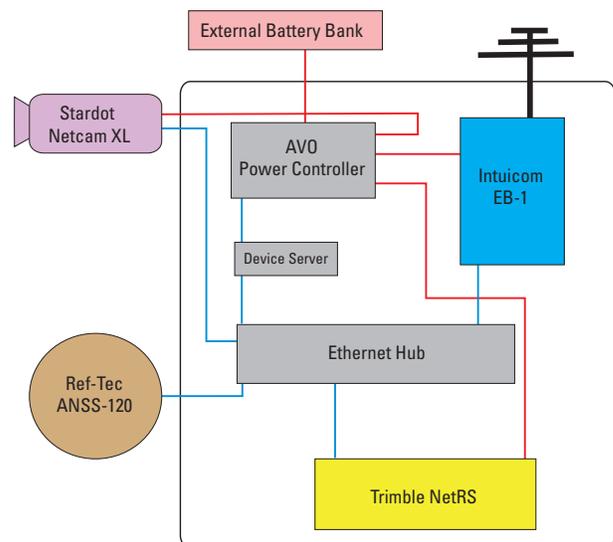
**Figure 3.** The Mound camera aimed at Augustine Volcano. The camera's housing has a protective debris- and snow-shedding shield of bent aluminum. The housing is attached to an Alaska Volcano Observatory (AVO) solar-panel mounting structure. AVO photo by M. Coombs, January 12, 2006.

intervalometer, and DC-DC inverter, and it had a lexan window plate through which images were captured. This box was attached to a larger fiberglass box that housed a 100A/hr lead-acid battery. The image interval of 15 minutes and image file size of approximately 600KB allowed for about 70 days of storage on a 4-gigabyte flash card.

The location of this camera allowed imaging of the north side of the volcano, where activity was focused during the continuous and effusive phases of the eruption. The camera captured much of the daylight eruptive activity in high resolution and allowed reconstruction of the sequence of events (Coombs and others, this volume; their fig. 4). In addition, incandescent lava and block-and-ash flows were often visible in nighttime images from this vantage during the effusive phase of the eruption (fig. 7; Coombs and others, this volume; their fig. 17).

## Lagoon Camera

A Stardot Netcam system was installed on a wooden hut at the Northwest Lagoon base camp on the west side of Augustine Island on September 10, 2006. This camera used an existing Plate Boundary Observatory (PBO) Intuicom radio

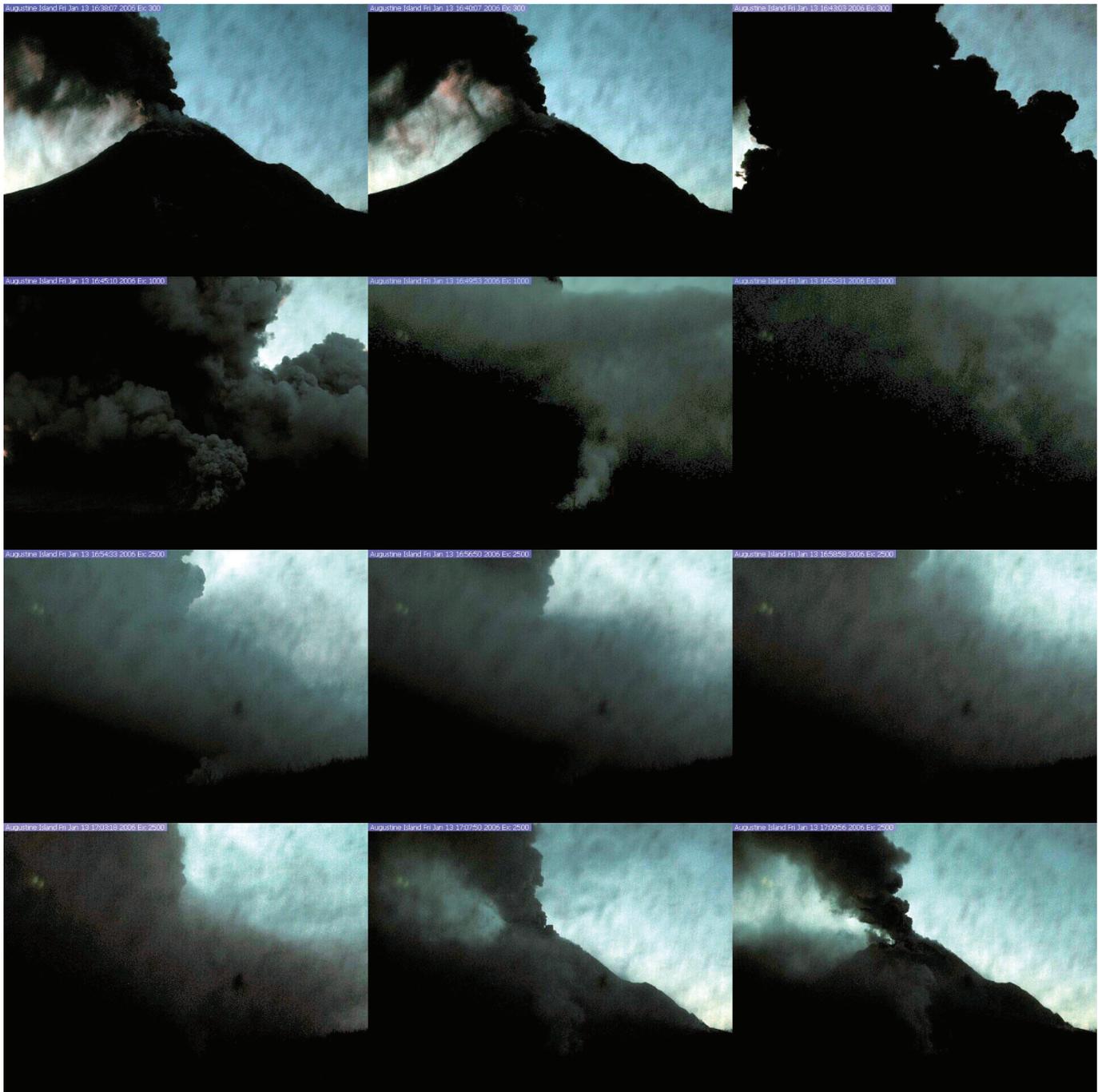


**Figure 4.** Block diagram of the Mound equipment package. Red lines indicate 12-volt DC power connections to the Alaska Volcano Observatory (AVO) power controller, while blue lines indicate data connections. The thin black line represents a Hardigg Storm Case iM2700, which houses electronic equipment.

network, as described in Pauk and others (this volume). The camera has an 8-mm lens. Image resolution was kept low, set to 320×240, and image upload interval was set to 2 images per hour in order not to impact bandwidth on the PBO network. Although this camera was not installed until after the eruptive activity, it was useful during post-eruption field operations (fig. 8) and is still operational in May 2010.

## Image Handling

Images were uploaded from the individual devices to a file server at AVO in Anchorage. Image retention on the file server was limited to allow for frequent synchronization with upstream processing systems. The AVO internal Web server retrieved new images from the file server at a scheduled interval. Once on the



**Figure 5.** Augustine Volcano eruptive sequence as imaged by the Mound camera. Images cover from 16:38:07 to 17:09:56 AKST on January 13, 2006. The sequence of images is from left to right in each row and top to bottom in rows.



**Figure 6.** Nighttime image of a lava flow from Augustine Volcano, captured on February 8, 2006, from the Homer Field Station using the Watec 120N low-light camera. The outline of the volcano is seen with the lava dome visible on the right side of the summit. The light colored foreground is snow which has bright spots where moonlight is being reflected.



**Figure 8.** Image captured by the Lagoon camera during field operations on Augustine Island on September 12, 2006, showing an Alaska Volcano Observatory (AVO) base camp.



**Figure 7.** Image of Augustine Volcano captured by the Burr Point time-lapse camera at 1747 AKST on March 6, 2006, during the effusive phase of the eruption. Incandescence is from growing lava dome and lava flows on the volcano's north flank.

internal Web server, the images were sorted into directories by date for long-term storage and retrieval. A pointer to the most recent image from each camera was maintained to allow it to be downloaded from a static URL. Images were available on the internal Web server within 5 minutes of their acquisition. Rapid creation of simple animations from each camera was made possible by stitching together individual images into an AVI file encoded with MJPEG.

The AVO public Web server retrieved images from each camera's static URL on a set schedule. The public server only maintained the most recent image from each camera. Images were available on the server within 10 minutes of their acquisition.

## Conclusions

The use of the Augustine remote camera systems established real-time visual observations of eruptions as a critical aspect of the AVO response. Near and far field cameras at multiple angles capable of imaging in all light conditions allows for critical hazard assessments, estimation of plume heights, accurate depositional chronology, and onsite weather/hazard assessments for field teams visiting an active volcano. The telemetered cameras are still operational as of May 2010 and AVO continues to use them as part of its monitoring repertoire.

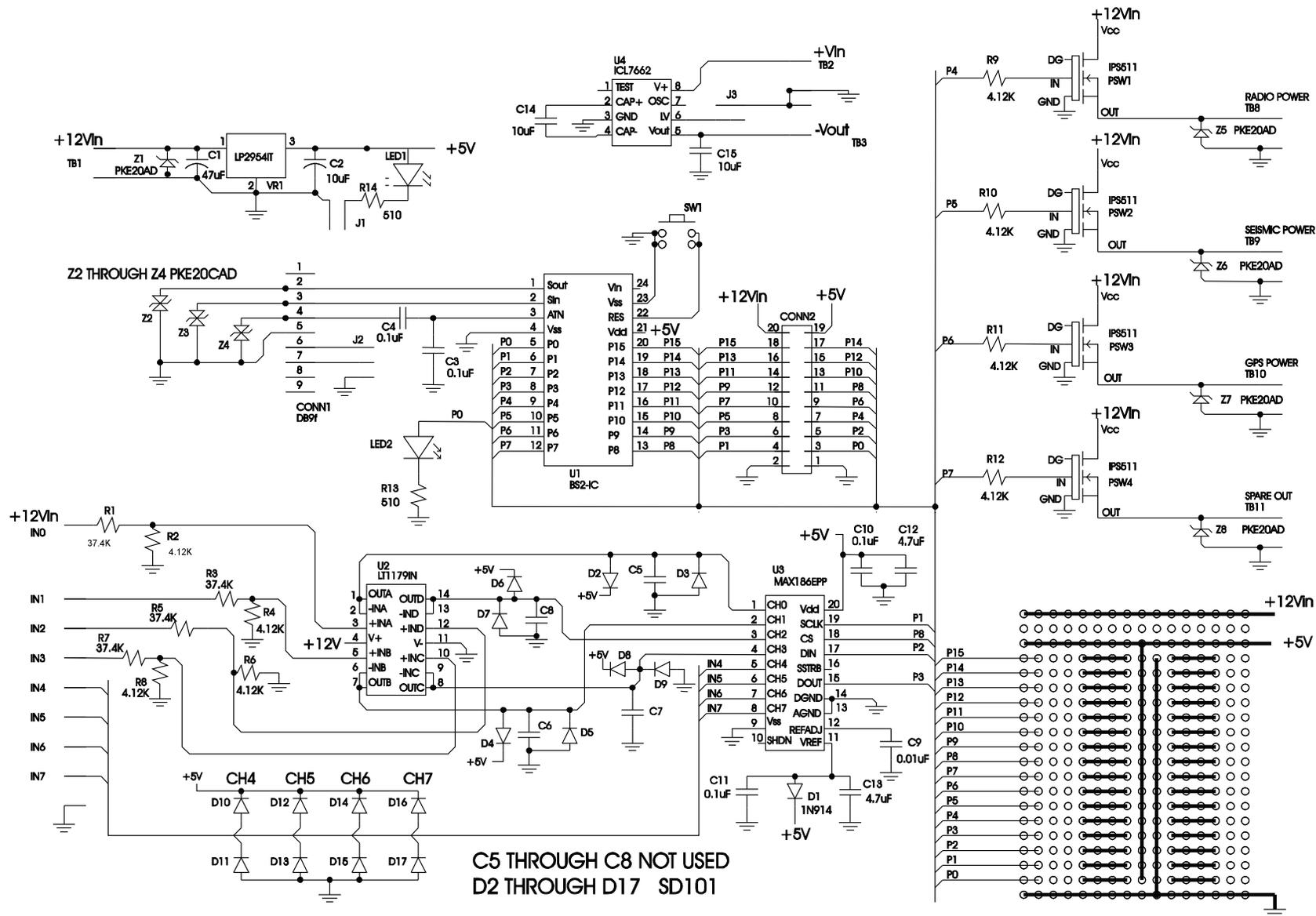
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## Appendixes 1 and 2

### Appendix 1. Product data sheets and manuals.

Equipment	Internet Link for Manual
Stardot Netcam MegaPixel	<a href="http://stardot-tech.com/netcam/netcam-brochure.pdf">http://stardot-tech.com/netcam/netcam-brochure.pdf</a>
Watec 120N	<a href="http://www.wateccameras.com/products.php?prod_id=124">http://www.wateccameras.com/products.php?prod_id=124</a>
Stardot video server	<a href="http://www.stardot.com/express6/specs.html">http://www.stardot.com/express6/specs.html</a>
Nikon COOLPIX 8700	<a href="http://www.nikonusa.com/pdf/manuals/coolpix/CP8700_en.pdf">http://www.nikonusa.com/pdf/manuals/coolpix/CP8700_en.pdf</a>
Harbortronics DigiSnap 2000	<a href="http://www.harbortronics.com/digisnap2000_manual.pdf">http://www.harbortronics.com/digisnap2000_manual.pdf</a>
Harbortronics voltage regulator	<a href="http://www.harbortronics.com/detail.php?id=45">http://www.harbortronics.com/detail.php?id=45</a>
Intuicom EB-1	<a href="http://www.intuicom.com/www/datasheets/INT_EB1_Datasheet.pdf">http://www.intuicom.com/www/datasheets/INT_EB1_Datasheet.pdf</a>



CAPACITORS LABELED WITH 'A' ARE  
0.2 PIN SPACING ALL OTHERS 0.1

## AVO CONTROLLER AND POWER SWITCH

AVO Power Controller as designed by Tom Murray, AVO/USGS

**Appendix 2.** Schematic of the Alaska Volcano Observatory (AVO) "Stamp" which allows remote power and timing control of devices.