H41S-2026

Slide Sentinel

An Automated Landslide Monitoring System Using RTK GPS

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OPEnS

ABSTRACT

- Landslides cost the United States an estimated $3.5 billion in infrastructural damage per year and claim the lives of 25-50 people annually. Regularly monitoring the activity of landslides with high spatio-temporal resolution and accuracy can provide valuable early warning information and aid in the interpretation of landslide kinematics.
- Slide Sentinel is a fully automated landslide monitoring network capable of determining landslide movement with centimeter-level accuracy for long term deployments.
- Field testing results drove the team to redesign the systems hardware in a modular, power efficient fashion. The design is now hardware ready to support a suite of GNSS receivers on both the base station and rover.
- The cost for a single rover and base station is **~$2800**.

PURPOSE: Alerts and Monitoring

- The Slide Sentinel consists of a centralized base station and a network of rover units which may be deployed over the extents of active landslide terrain.
- Rover units on the network wake at configurable intervals, receive RTK correctional data from the local base station, and produce a positional reading.
- Readings are sent to the base station and are uploaded via an Iridium satellite link to a Google spreadsheet for real-time updates of rover movement.
- Rover units come equipped with an accelerometer capable of waking the device in the event of sudden movement. Upon waking due to such an event, rover units send a high-priority emergency wake message which is immediately uploaded via satcom by the base station. Alert thresholds are programmable to 6-millig sensitivity.
- After uploading a positional string, rover units enter a low-power, sleep state wherein they consume ~15mA.

Landslide in Alsea, Oregon from the base station location. The scheduled first deployment location of the Slide Sentinel. A ¾ mile wide landslide with an over 50 foot main scarp.

Proposed base station setup at the deployment location. Perched atop a ridge overlooking the slide at approximately one mile baseline. Base station setup includes two 20 watt solar panels.

Contact Information

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COMPONENT BREAKDOWN

OEM Components:

- **Adafruit Feather M0:** 48 MHz Microcontroller using ARM's SAMD21 Microprocessor
- **Freewave Z9-T/Z9-C:** High-performance RF link between the base station and rover
- **Polulu D36V28FX:** Power regulator for compatibility with any 12 volt power source
- **Rockblock+:** Iridium satellite modem for base station telemetry in remote locations
- **Swift Piksi Multi:** Current GNSS receiver undergoing system integration. Decent performance-price ratio.

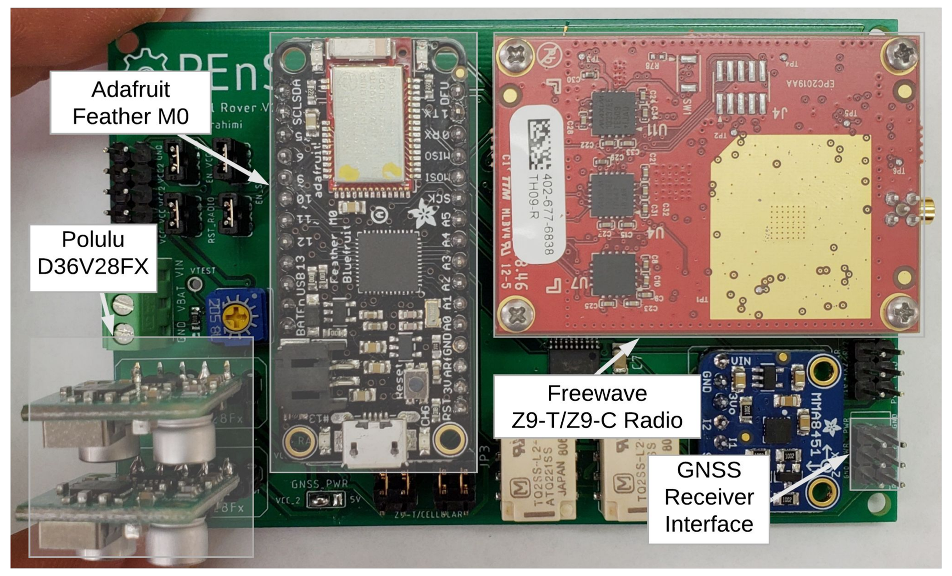
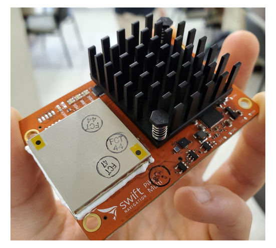


Figure 1. Rover PCB with OEM components

Rockblock+



Swift Piksi Multi

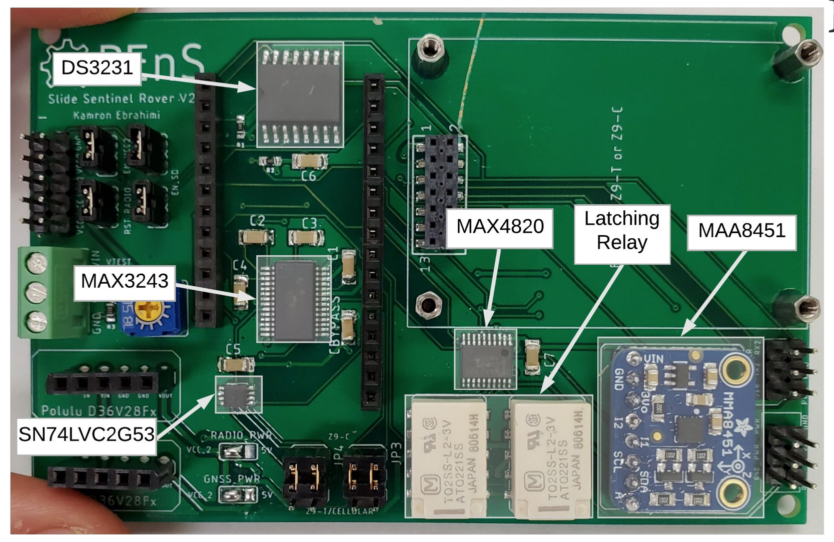


Figure 2. Rover PCB without OEM components

Integrated Circuits:

- **DS3231:** Real Time Clock
- **MMA8451:** Accelerometer
- **MAX4820:** Low-side relay driver for driving the latching relays over SPI
- **SN74LVC2G53:** Analog switch for routing command and correctional data
- **MAX3243:** RS232 Interface for use with Freewave Z9-C
- **Latching Relay:** Power switching relays for the radio and GNSS receiver

METHODS

1.) Rovers on the network wake at programmable intervals using the real time clock or wake asynchronously from accelerometer interrupts.

2.) Once awake, rover units perform a handshaking protocol with the local base station. During this handshaking process the base station will dispatch any queued configuration data to the rover. This configuration data can tell the rover to wake more or less frequently.

3.) Both devices switch their analog multiplexer and RTK correction data begins to flow from the base station's GNSS receiver, over the RF link, and into the GNSS receiver on the rover in an attempt to produce an centimeter-level RTK fix.

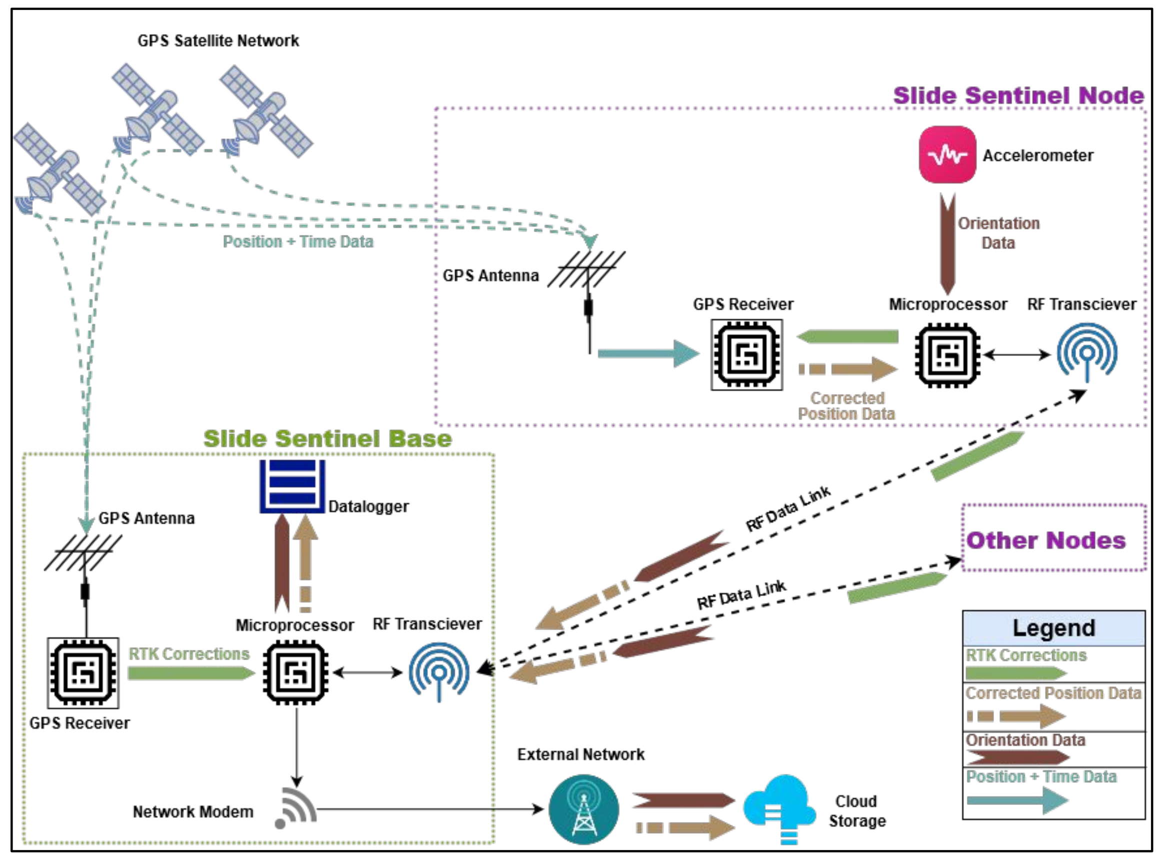


Figure 3. Slide Sentinel data flow diagram

4.) The rover informs the base it is done producing an RTK fix, uploads its positional reading to the base station, sets a wake up alarm, and enters low power sleep.

5.) The base station saves the uploaded rover position to SD, and performs a satellite upload using the Iridium satellite modem. Utilizing RockBlock webhooks we can update the data directly in the Google Sheet

Latest Updates

- Slide Sentinel is currently undergoing testing of rovers in a field at the Oregon State University campus.
- Current slide sentinel rovers are being outfitted with new mounting brackets for the RF antenna and the GNSS antenna atop the rover.
- Code has gotten a full rework and been completely updated to allow for longer sleep times and less power consumed over the course of operation.

Base Antenna Mount Bar

Rover Antenna Mount Bar in the CTEMPs Testing Site

Performance

- Field testing revealed that the perform poorly in canopied environments and will on occasion produce inaccurate RTK fixes.

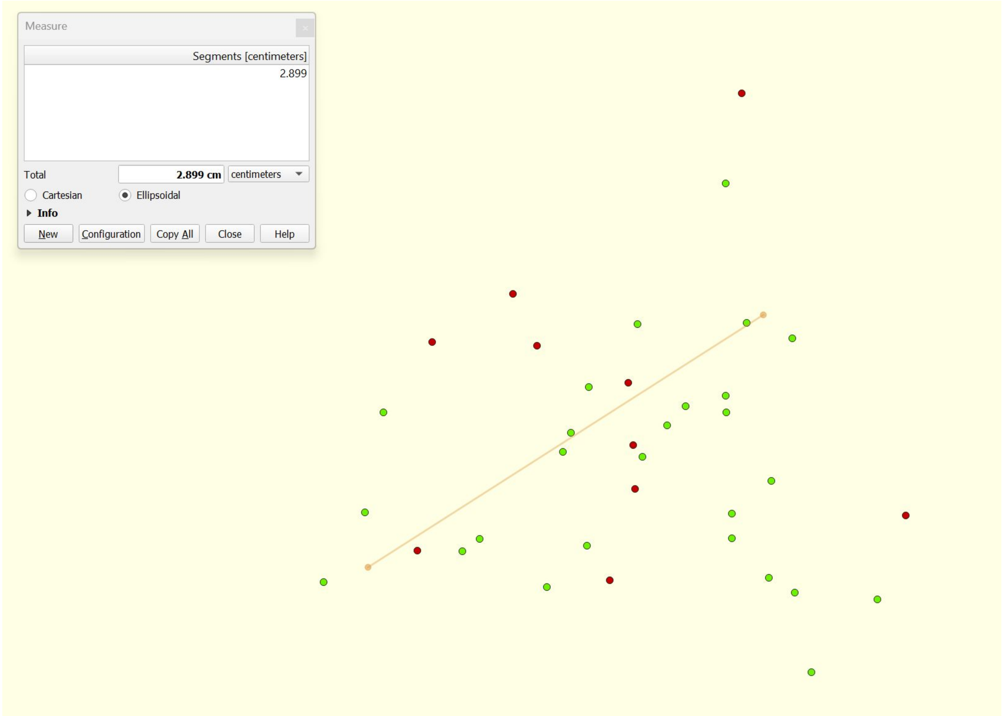


Figure 5. The data shows two distinct logging periods of data. The green points are from a logging period that lasted from 8am - 1pm on February 16th (PST) While the green points are from 4pm 2/15 - 12am 2/16. The base battery ran out of power due to not having enough sunlight causing the two groupings

- To further test performance of the GNSS receiver, the duration for which the device remained awake was variably increased. These tests showed that the Piksi Multi needed to generate 300 RTK fix NMEA strings to ensure the fix was centimeter-level.
- The GNSS receiver needed to generate "high" precision RTK strings for 7 minutes in order for the generated string to be valid.

CONCLUSIONS: FUTURE DIRECTION

- These findings drove the team to develop modular hardware capable of interfacing with any GNSS receiver.
- We are looking into having intelligent scheduling to improve performance and longevity of the system
- The team is focused improving hardware reliability by moving away from jumper cables and implementing picoblade or barrel jack connectors for every external board connection.

ACKNOWLEDGMENTS

This work is/was supported by the USDA National Institute of Food and Agriculture, Hatch project (Regular Research Fund, ORE00218, ORE00218A), NSF 1832170.

Special thanks to Chris Parish, Chase Simpson, and Richard Slocum for their time and materials that have gotten this project off the ground.

Special thanks to all previous contributors on the project including Grayland Lunn, Marissa Kwon, Cyrus Swihart, Isaac Goshay, Elijah Shumway and Gianluca Rianda