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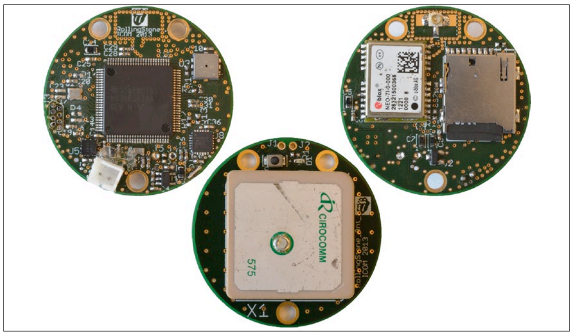
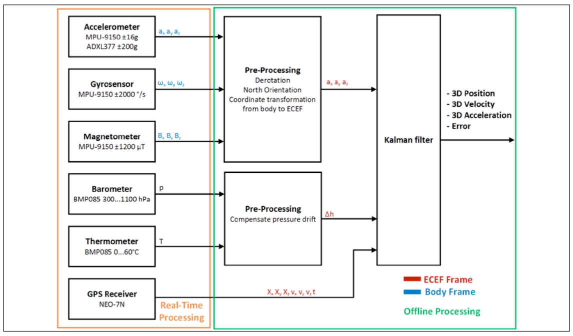
Project Partner	Eidg. Forschungsanstalt für Wald, Schnee und Landschaft WSL, Birmensdorf ZH

Position and velocity measurement of rock falls

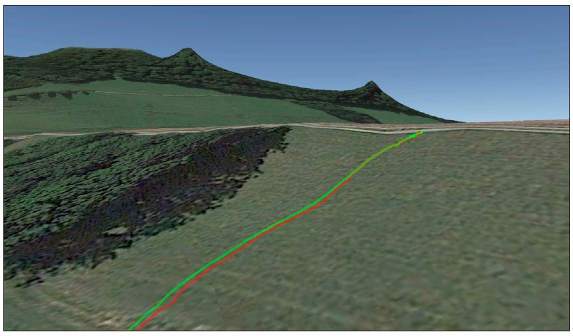
Using a GPS-aided inertial navigation system



Top: main board, bottom: antenna board



GPS-aided inertial navigation system overview



Position measurement of a rock fall (green: Kalman filtered data, red: raw data)

Introduction: This project was carried out on behalf of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). One field of their activity lies in the research of rock falls. As well as simulations of rock falls, field tests are carried out in which the position and velocity of rocks are measured and recorded for further data processing. With the help of this data, protective equipment can be developed to reduce the risk of damage to the environment and population. Until now, rock falls were recorded on videos and manually analysed. This method is very time-intensive and it is too inefficient to create statistical rock fall models.

Objective: A more efficient method to measure the position and velocity of rock falls must be developed. Therefore an inertial navigation system which contains a 3-D accelerometer, 3-D gyro sensor, GPS receiver and other sensors to measure position and velocity must be implemented. The system has the ability to log all data for further offline processing. To achieve an improvement in accuracy, the data should be processed by a Kalman filter. The error variance could thus be significantly reduced. The goal is to build a system for tracking the position and velocity of falling rocks with more efficient offline data processing algorithms and without loss of accuracy.

Result: The final result is a device which is installed in a rock and records the data of the sensors and the GPS receiver, and logs them on a micro SD Card. The device has the following sensors installed:

- 3-D ±16 g Accelerometer
- 3-D ±200 g Accelerometer
- 3-D ±2000°/sec Gyroscope
- 3-D ±1200 µT Magnetometer
- Temperature and Pressure Sensor (0.25 m Resolution)
- u-blox NEO-6N or NEO-7N GPS Module

The sensor data is processed offline in a Matlab programme that determines the position and velocity of the falling stone. In a first step, the acceleration data is rotated into the ECEF coordinate system with the help of the gyroscope and the magnetometer. This is required for later data fusion with the GPS data in the Kalman filter. A loosely coupled Kalman filter is implemented after the data pre-processing. The results show a precision up to 1 m in position and up to 1.5 m/s in velocity, depending on the environment.