SUBSURFACE VIEWS

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IceMap™ GPR: Bringing Remote Communities Closer Together

For many remote communities in the north, transportation is not something taken for granted. Large distances between towns, accessibility of roads and cost of transportation are real concerns faced by residents every day. While most of us in the 'south' think of winter driving as a nuisance, in the north, winter provides greater access to travel as rivers freeze and become temporary ice roads. In the Northwest Territories in Canada, ice roads form a vital transportation link for cheaper and more efficient shipping of goods. In Alaska along the Kuskokwim River, however, it's more than just about saving money; it's essential to their way of life.

Figure 1: Geographic location of the Kuskokwim River and surrounding communities

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In winter, the 250-mile ice road along the Kuskokwim River connects over 15,000 people in several communities (Figure 1). In an area where resources are hard to come by, it's all about the people: their ingenuity, cooperation and commitment to safety. It starts with those who watch the river ice, especially during times of winter freeze and spring thaw. They depend heavily on traditional knowledge; based on experience they know where strong currents may delay ice formation in the fall or accelerate ice breakup in the spring. These ice conditions are communicated to the communities up and down the river to ensure safe transportation. One of these communities is the Native Village of Napaimute, who recently enhanced their safety process by purchasing an IceMap™ GPR system for checking ice thickness. Rather than drilling holes at regular intervals for verification, IceMap™ provides a continuous measurement of ice thickness, so thin spots are immediately identified.

Figure 2: Towing IceMap behind a truck, following a snow plow

"By combining our traditional knowledge with new technology, we are able to manage safe travel despite a changing climate that produces less ice," said Mark Leary, Director of Development & Operations at the Native Village of Napaimute. Warmer weather is leading to shorter seasons and more variability in ice conditions. Heavy plowing equipment is used to keep the road clear of snow, but the plow can only go on once the ice is thick enough. IceMap™ is used at the start of the season to make sure the conditions are safe to start plowing (Figure 2). Then it is used during the year to monitor ice thickness and locate dangerous, thin spots of ice.

"The ice is a living thing with a life of its own," Leary said. "We watch it be born, we watch it mature all winter, and we watch it die in the spring."

A stable, maintained ice road has wide ranging implications for social and economic reasons. Some examples include:

- hauling fuel, timber, building supplies
- moving small homes on a truck
- driving to a medical clinic in a nearby village
- a high school basketball tournament, where participants and their families can affordably drive to the community, rather than the more expensive option of flying

The benefits of the ice road reach beyond just that of the villagers as many government agencies also use this road.

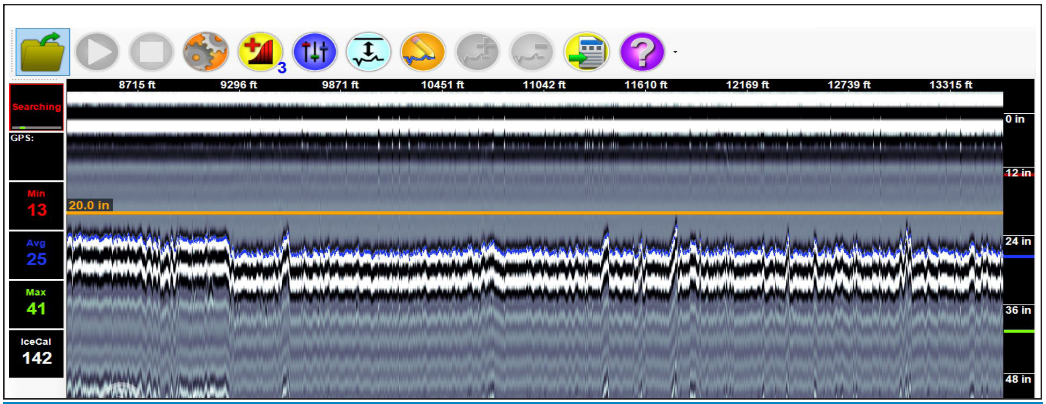

Figure 3: Data collected with IceMap. The blue line shows the thickness of the ice along a route.

IceMap data can be viewed in real-time (Figure 3), but it can also be downloaded, and an automated summary report generated. The report gives an overview of ice conditions, where ice calibrations (ground-truthing) were done, as well as highlighting areas of thin ice. For more graphic viewing, data can be overlaid onto Google Earth showing ice thickness along the path travelled.

"The Ice Map system has become a valuable asset in helping us adapt our winter travel strategies to keep people safe in the face of the changing climate", says Mark. Their unofficial motto is: *Working together so others may live.*

Story courtesy of Native Village of Napaimute

pulseEKKO® Ultra Receiver: Customer Stories

The pulseEKKO® Ultra Receiver, which operates with 12.5, 25, 50, 100 and 200 MHz antennas and stacks data traces up to 65,536 times, has been available for more than one year now and we thought it would be a good time to share a few real-world results from our customers who have been using this new technology in the field.

Dr. Sarah Kruse from the University of South Florida with her students, PhD candidates Danielle Molisee and Elisabeth Gallant, used an Ultra Receiver as part of an interdisciplinary investigation of the eruptive history of Medicine Lake Volcano in Northern California.

Danielle Molisee states, "The Glass Mountain eruption (~870 yrs B.P.) blanketed the area in tephra and buried the evidence of some earlier eruptions. We're using GPR to reveal these hidden eruptions (Figure 1). Considering this new information, we can much better understand the past behavior of this volcano, which in turn, should help us to better forecast future behavior."

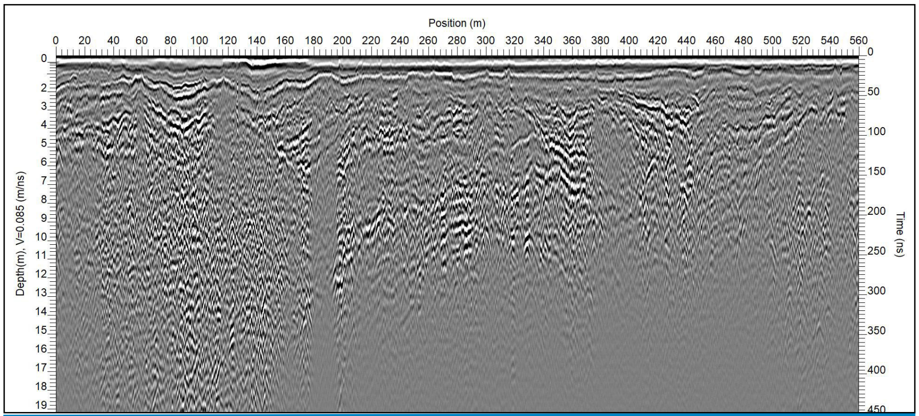

Figure 1: Volcanic boundaries and structures to depths of 20+ meters near the Medicine Lake Volcano.

Dr. Harry Jol and his students, from the University of Wisconsin at Eau-Claire, collected pulseEKKO® Ultra Receiver data at a site in Lithuania suspected of being used by the Nazis for the mass execution of Jews in 1941-44. Previous work at the same site showed the soil has high electrical conductivity that limited GPR signal penetration. By stacking each trace 16,384 times, the depth of penetration of the 200 MHz antennas more than doubled (Figure 2b) when compared to stacking once (Figure 2a); resulting in the detection of deeper features than ever before.

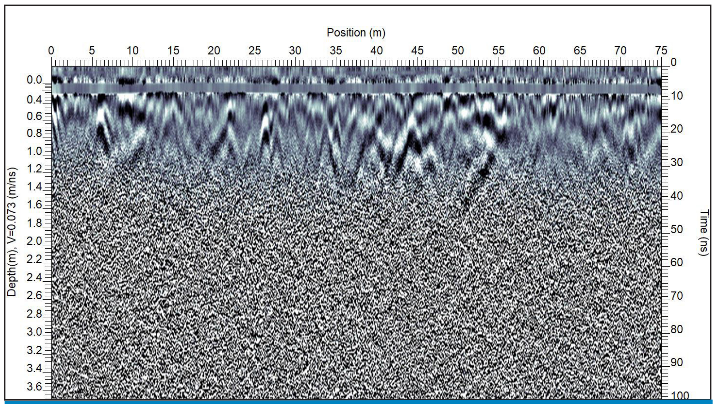

Figure 2a: 200 MHz data collected with 1 Stack at a suspected Nazi execution site in Lithuania.

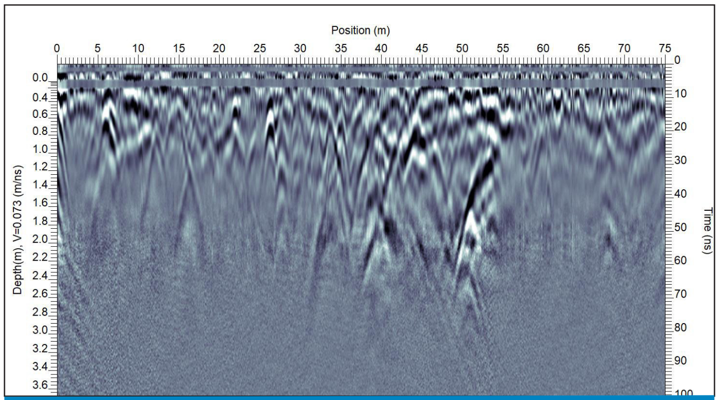

Figure 2b: The same GPR line as Figure 2a but collected with 16,384 Stacks; reducing the noise floor and doubling the depth of penetration.

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Michael Powers from the U.S. Geological Survey is using the Ultra Receiver with his pulseEKKO® borehole GPR system to detect weaker GPR signals travelling between boreholes. He typically collects ZOPs, Zero Offset Profiles (Figure 3) where the transmitting antenna and the receiving antenna are lowered down two boreholes at the same time and data collected at equal intervals.

The increased stacking provided by the Ultra Receiver means that weaker GPR signals can now be detected as they travel from one borehole to the other, providing more information about the properties of the materials between the boreholes.

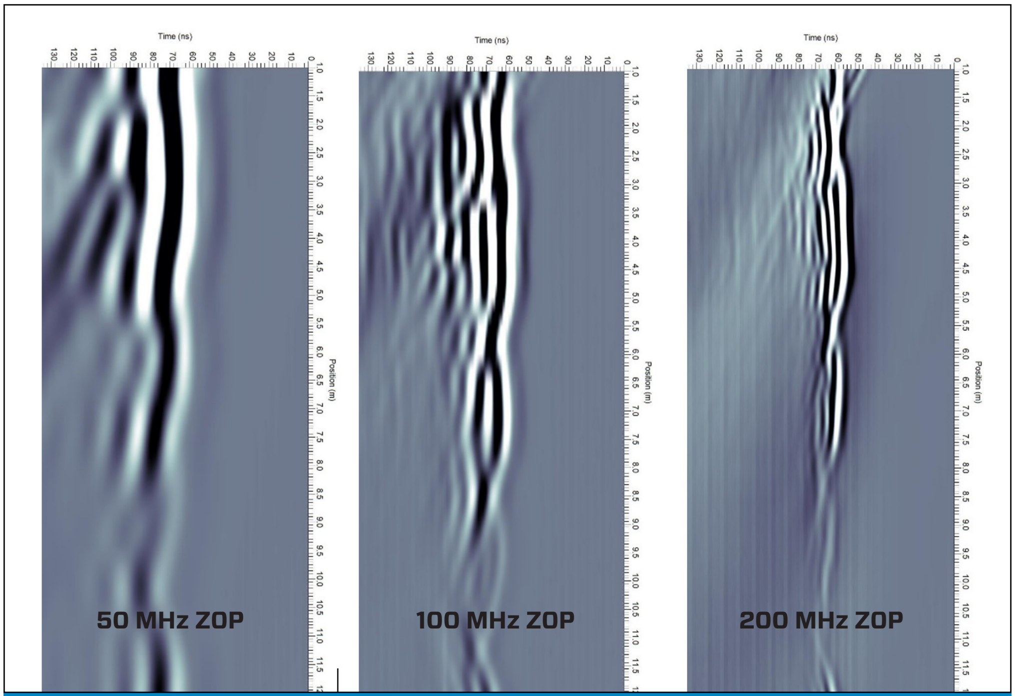

Figure 3: Zero Offset Profiles (ZOP) collected using 50, 100 and 200 MHz borehole antennas.

Another American researcher recently used the Ultra Receiver for an extensive survey in a glacial environment with the purpose of mapping the subsurface glacial, glaciofluvial, and glaciolacustrine geology (Figure 4).

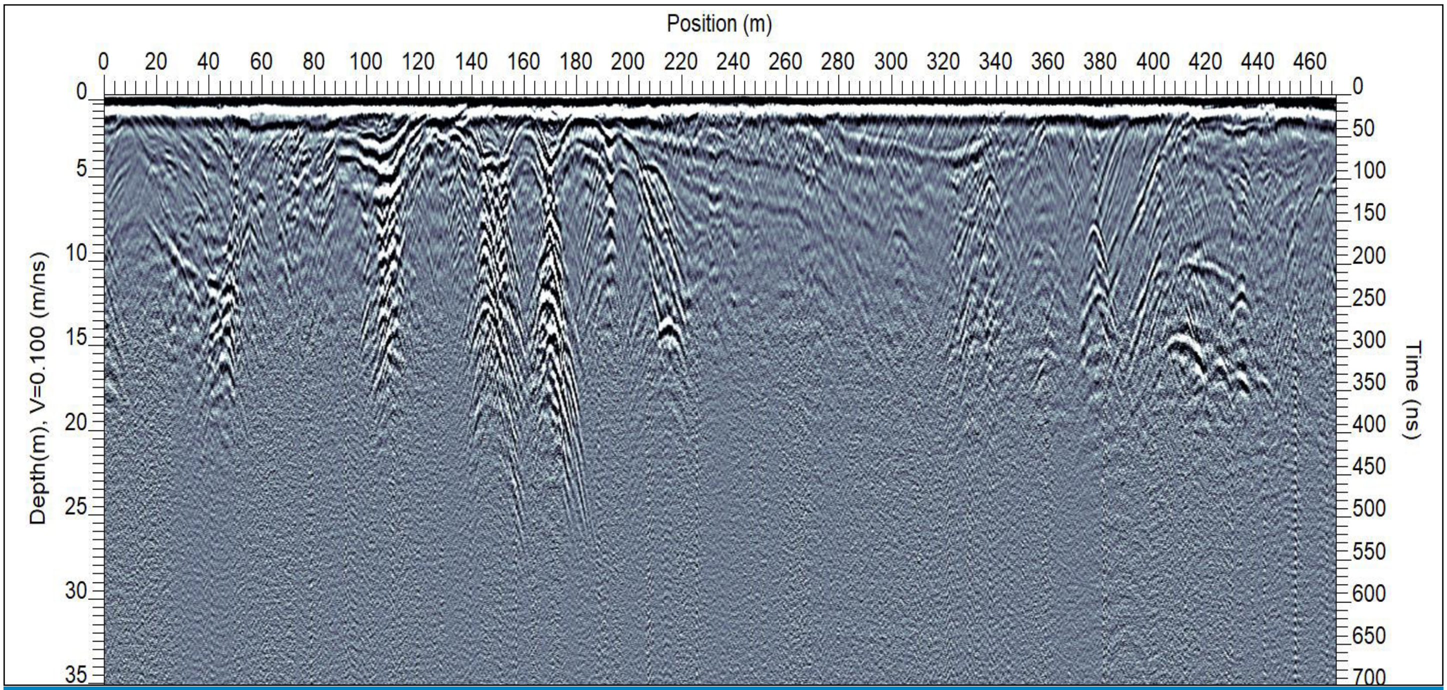

Figure 4: A long GPR line collected in a glacial environment in the USA with 50 MHz antennas shows reflectors 20+ meters deep.

As these examples show, the pulseEKKO® Ultra Receiver is proving itself in many varying applications by increasing the depth of penetration, even in areas with high signal attenuation.

We thank those who contributed and allowed us to share their data and stories.

TIPS: Enhancing GPR Targets by Filtering

The menu item "Filter" is short for "Background Subtraction Filter". It is applied to remove flat-lying signals (signals that arrive at the same travel time or depth) that are present in ALL traces in the GPR line; typically, the direct air and ground arrivals at the top of the section (Figure 1) or system noise bands. These undesired signals can interfere with desired signals such as hyperbolas from subsurface objects.

The most common background subtraction filter is to subtract the average of all the traces. While effective, some flat-lying features do not extend over the whole survey line and therefore are not removed. Reducing the width of the filter from an average of all traces to a shorter length of traces is very effective for removing more localized flat reflectors. These are typically real reflections from flat-lying objects and boundaries in the subsurface which can mask the response of more localized targets.

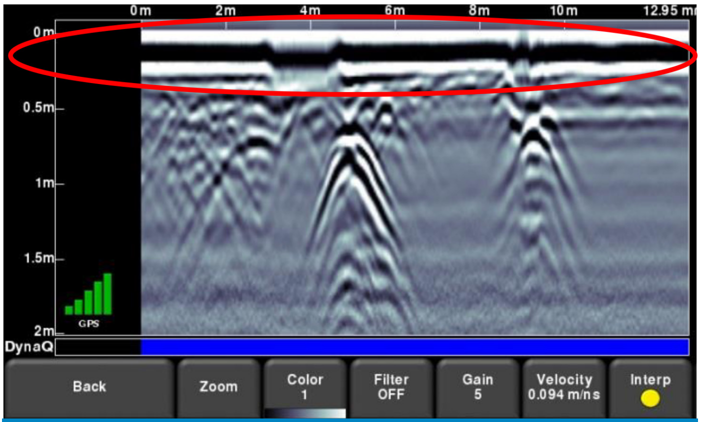

Figure 1: All CONQUEST®100, NOGGIN®, pulseEKKO®, LMX100™, LMX200™ and FINDAR® GPR systems have the Filter button available on the screen during data collection and review in the field.

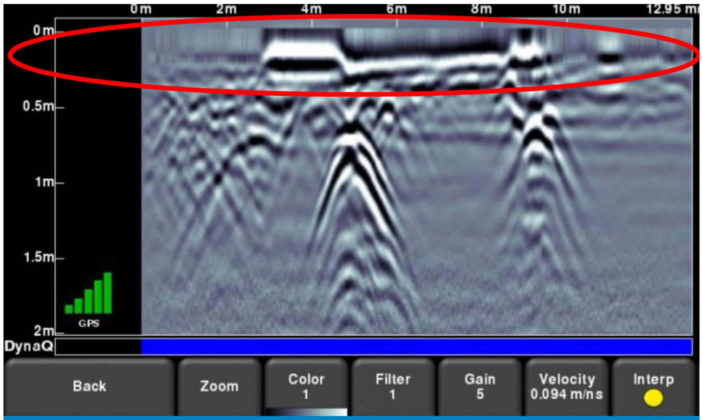

Figure 2: Level 1 of the Filter tends to remove flat-lying signals present in ALL GPR traces; such as the direct arrivals from the GPR transmitter to the GPR receiver visible at the top of all GPR lines (circle above). Compare Figure 1 (no filter) and Figure 2 (filter set to Level 1)

Why would I want the filter to do this? Most GPR data targets that people are interested in are point targets that create hyperbolic responses in the GPR data, either true point objects that archaeologists or forensic investigators are interested in, or the hyperbolas caused by crossing perpendicular to the alignment of linear objects, such as buried pipes and cables.

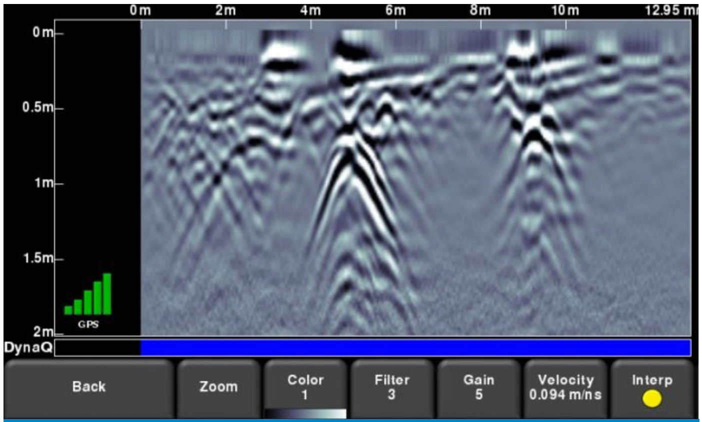

Figure 3: Level 3 of the Filter removes moderately long flat-lying signals in the data. In this example, notice how the 2-meter-long flat reflector, from position 3 to 5 meters in Figure 2, is now removed by the shorter filter width.

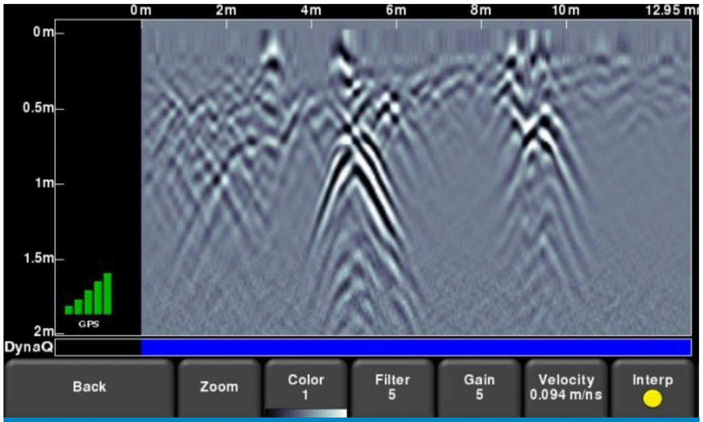

Figure 4: With the Filter set to Level 5, all flat reflectors have been removed from the GPR line, revealing very weak hyperbolas that may be targets of interest.

Changing the width of the background subtraction filter removes flat reflectors of shorter width so that hyperbolas from targets are enhanced and more visible in the data.

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You can quickly toggle through filter levels 1 to 5 to find the best filter setting for your data. The lower the number, the longer the filter width, and the more “relaxed” the filter; only longer flat-lying features get removed (Figure 2). The higher the filter number, the shorter the filter width, and the more “aggressive” the filter. This results in the removal of long and short flat-lying features. Figures 2, 3 and 4 show a gradual change of the filter width and the effect this has on data. Pressing OFF turns the filter off completely (Figure 1).

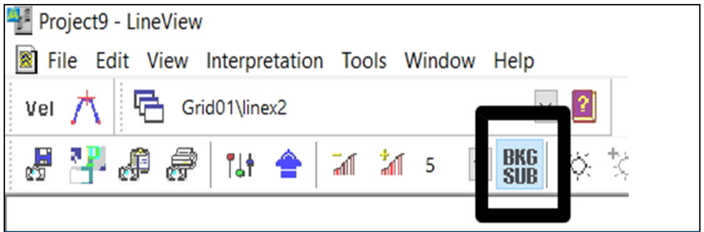

Figure 5: The Background Subtraction Filter button is accessible from the toolbar of the LineView software module.

The Filter button is present on Sensors & Software GPR systems (Figure 1) as well as the LineView module of the EKKO_Project™ GPR Analysis PC software (Figure 5).

In the LineView module of the EKKO_Project™ software, the filter width is changed in the **View > Settings > Gain/Filter > Filter Width** menu option. In EKKO_Project®, the filter allows you to set the physical length of the background subtraction filter for finer tuning during post-processing.

Remember that applying the Filter to your data does not affect the saved raw data; the filter only modifies the displayed image, so there is no harm in trying it to see if it helps your data interpretation.

With GPR lines that have many reflections from boundaries masking hyperbolas, shortening the background subtraction filter width may be the critical step in identifying the target.

Upcoming Courses

Subsurface Utility Locating with GPR course (NULCA-accredited)

- November 4, 2019, Mississauga, ON, Canada
- January 13, 2020 Mississauga, ON, Canada

Concrete Scanning with GPR course

- November 5, 2019, Mississauga, ON, Canada
- January 14, 2020, Mississauga, ON, Canada

Free Webinar - Advanced features of LineView - November 20, 2019

Upcoming Events

(IRF) Global R2T Conference & Exhibition - November 19-22, 2019, Las Vegas, NV, USA

The Buildings Show - December 4-6, 2019, Toronto, ON, Canada

(AGU) American Geophysical Union December 9-13, 2019, San Francisco, CA, USA

Canadian Concrete Expo - January 22-23, 2020, Mississauga, ON, Canada

(WOC) World of Concrete - February 4-7, 2020, Las Vegas, NV, USA

Sensors & Software Inc.

1040 Stacey Court
Mississauga, ON
Canada L4W 2X8

+1 905 624 8909
+1 800 267 6013
www.sensoft.ca

Sensors & Software Europe GmbH

Bergstrasse 63a
D-56203 Höhr-Grenzhausen
Germany

Office: +49 (2624) 915 9353
Fax: +49 (2624) 915 8097
europe.sensoft.ca

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