INNOVATION: Understanding and Using Multipath

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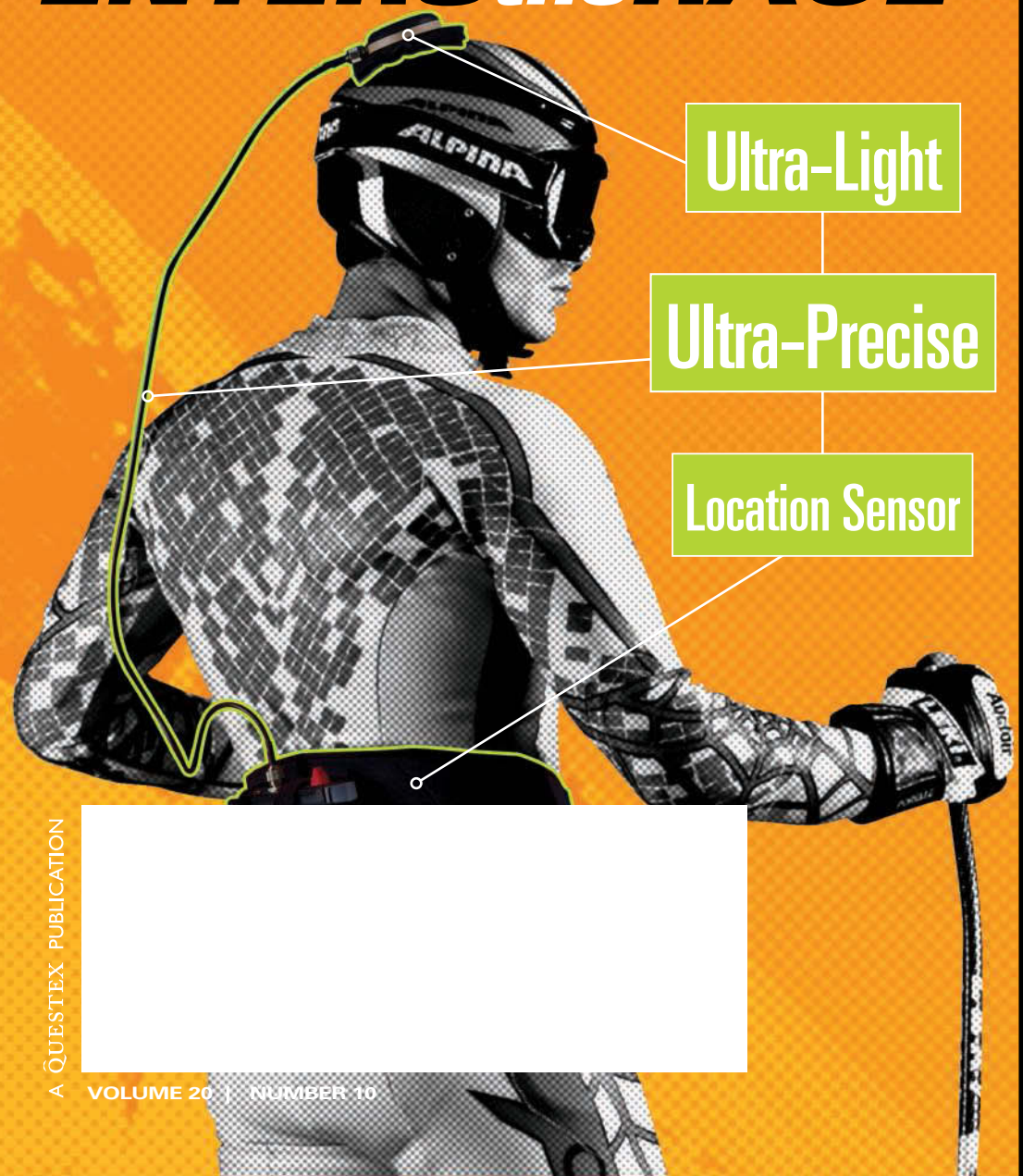
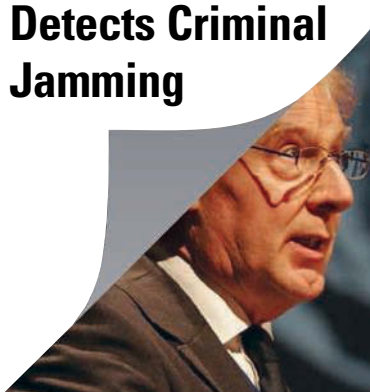
STEALTH ENTERS the RACE





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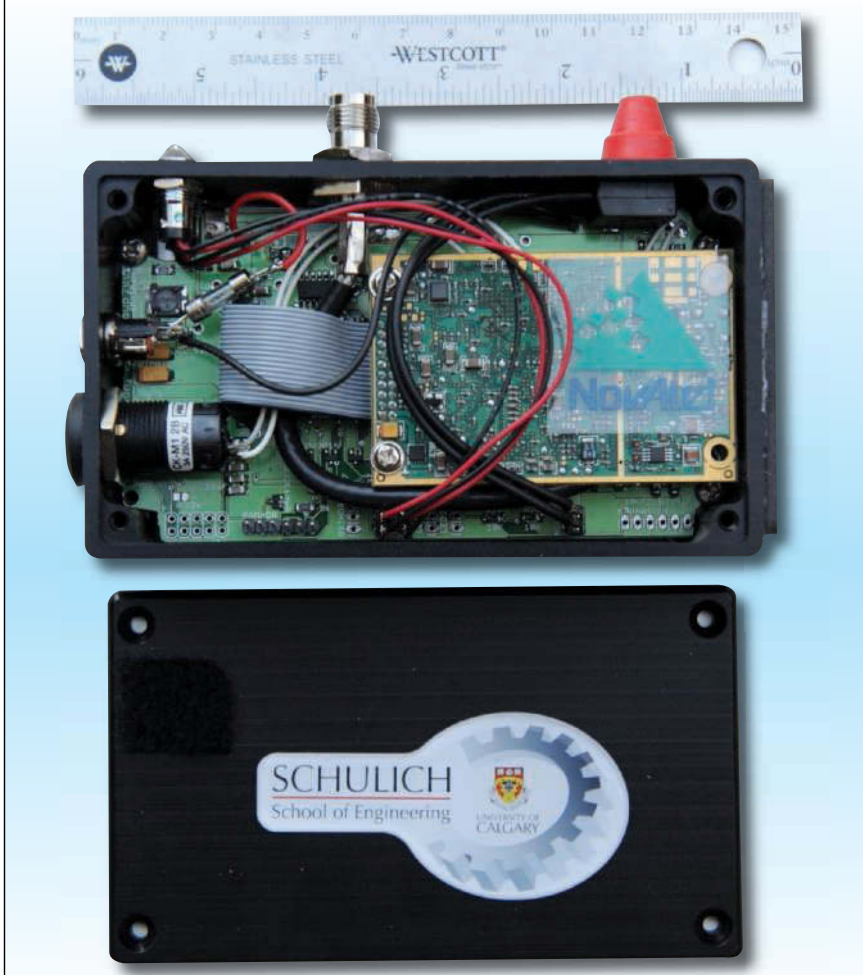


Elite Sensor Training

Competitive alpine skiers win or lose races by fractions of a second. Research has explored GNSS potential to provide position information to skiers and instructors during training. However, to date the size, weight, autonomy, accuracy, and availability performance have posed major obstacles to use.

The Sensor for the Training of Elite Athletes (STEALTH) overcomes these limitations to provide a racing edge for Canadian alpine ski teams.

By Gérard Lachapelle, Aiden Morrison, Richard Ong, and Gerald Cole

A top-secret program launched in 2006 by Canadian sports authorities enlisted the University of Calgary's Positioning, Navigation, and Wireless Location (PLAN) Group of the Schulich School of Engineering to develop an ultra-precise, ultralight GNSS-based device that would meet the requirements of the Canadian Alpine Ski Team (CAST) to enhance its training leading to the Vancouver 2010 Olympics.

The targeted specifications for the system were set to allow it to detect relevant differences in line selection between elite-level skiers for the downhill, super-giant slalom, and giant slalom disciplines, and to operate in ambient conditions below −20 degrees Celsius with the potential for moisture. For safety reasons, the system had to have a negligible influence on the skiers at speeds in excess of 120 kilometers/hour.

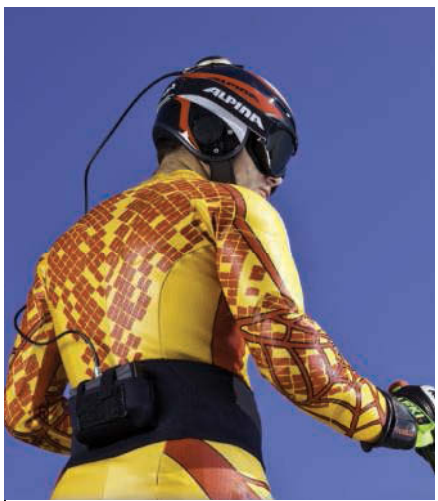
A key desired specification called for an accuracy better than 20 centimeters in position and 1 millisecond in timing sampling at a minimum of 20 Hz, using a wearable device that would not exceed 500 grams and would have an autonomy of at least 4 hours.

Starting Gate. Development and testing during winter 2006–07 led to a prototype system undergoing successfully testing in April 2007 by the ski team. Subsequent to the excellent prototype performance results, a second generation system of the wearable equipment was designed for use by CAST.

These systems, known individually as Sensor for the Training of Elite Athletes (STEALTH), were adopted by CAST starting in fall 2007, and have been successfully and continuously used since, both in the original capacity of athlete training, and in an expanded role where the system's strengths are leveraged for the performance-based evaluation of ski equipment.

The STEALTH wearable hardware size and capabilities make it extremely compact, lightweight, and easy to maintain, ideal for extended field use and in situations where the user must have total freedom of movement. With outer dimensions of only 3.7 by 7.8 by 12.9 centimeters, and a mass of less than 280 grams, the unit is light enough to be hardly noticeable by the user, and small enough to be carried without affecting natural range of motion or burdening the athlete with external components.

Styles For The Slope. The belt-borne component is shown in the opening



▲ **STEALTH** mounted on stretchable belt and helmet-mounted GNSS antenna.

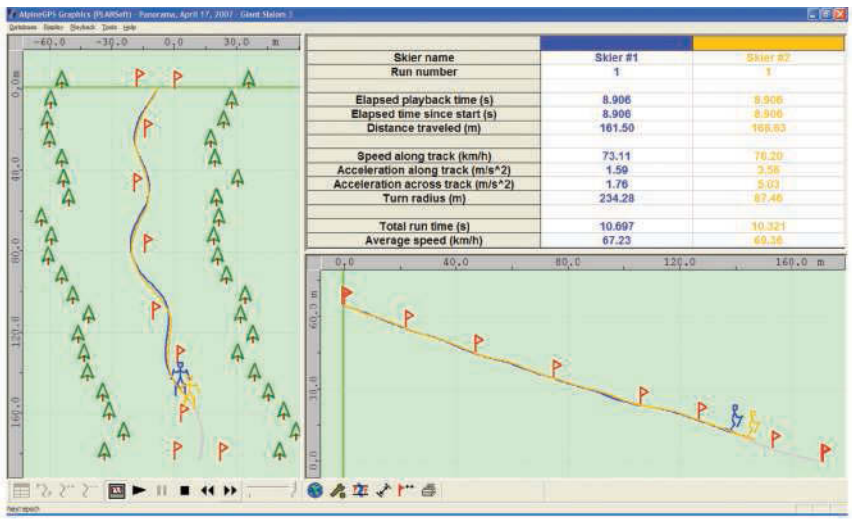
PHOTO. It includes a multi-channel L1 OEM V1 GPS/GLONASS unit and a proprietary embedded system to control power management, data storage, and operation on the slope in two modes: by the skier in training mode, and by an instructor to position gates along the course. Operation must be feasible with minimal training.

User interaction occurs through one button, with two lights indicating operating status. The raw navigation, code and carrier-phase data is recorded for post-mission use, as real-time operation is not required for the training of alpine skiers.

High-Elevation Mask. To obtain the highest possible level of accuracy and repeatability for the system, the system is operated in differential mode with a reference station set up at a convenient location on the course. In mountainous regions where training is typically conducted, slopes of 35 degrees are common, and performance must be maintained under these conditions. To provide the best possible performance in environments where high-elevation mask angles will be encountered while the skier is also subjected to varying orientations, it was necessary to select a high performance yet compact antenna.

Additionally, while the system was initially developed using GPS alone, it now includes both GPS and GLONASS to provide optimal performance in the aforementioned challenging environments.

GPS/GLONASS antennas weighing less than 150 grams with a diameter of 5 centimeters and thickness of 1.4 cm are mounted on the helmet. The current autonomous internal power typically ranges between 5 and 8 hours under low temperature ski conditions. The removable data storage capacity is 24 hours. The GNSS data is post-processed using PLANSoft, a kinematic carrier-phase software that processes GPS and GLONASS data using a fixed integer carrier phase ambiguity resolution approach.



▲ **SOFTWARE** screen capture

In addition to various time and position estimates, other parameters of interest to skiers and instructors are derived, including speed along track, accelerations, and turn radii.

When the GPS-GLONASS system is considered available, which is occurring about 80 to 90 percent of the time under the current combined constellation, timing accuracy is better than 1 millisecond.

Under these conditions, the carrier phase ambiguities are usually resolved as integer numbers and the position accuracy is better than 5 centimeters. The ski teams are now using more than 25 units on a routine basis during their training.

Acknowledgment

Alpine Canada Alpin (ACA) and **Own The Podium/A Nous le Podium 2010,** a national sport technical initiative designed to help Canada's winter athletes win the highest number of medals at the 2010 Olympic Winter Games in Vancouver, collaborated with GNSS researchers at the University of Calgary on this project.

Manufacturers

A multi-channel **NovAtel** *(www.novatel.com) L1 OEM V1* GPS/GLONASS unit was used, with **ANTCOM** *(www.antcom.com)* GPS/GLONASS antennas.

EVENTS

13th IAIN World Congress

*October 27–30, 2009, Stockholm, Sweden*Copy
http://www.congrex.com/nnf/iain2009/welcome.asp

The Nordic Institute of Navigation hosts the tri-annual congress of the International Association of Institutes of Navigation (IAIN.) The program covers the latest developments within civilian and military navigation and positioning on land, sea, air, and space. *GPS World* editor **Alan Cameron** and Tech Talk blog moderator **Dorota Brzezinska** will co-chair a session on Land Applications.

Telematics Munich 2009

November 10–11, 2009, Munich, Germany
www.telematicsupdate.com/munich/

The annual Telematics Munich 2009 Conference & Exhibition is for the European telematics industry, according to organizers. This year's senior-level speakers will include executives from BMW, Audi, Magneti Marelli, Fiat, Nokia, Google, Volkswagen, Continental, and Yahoo! We expect to publish coverage in the December issue by correspondent Moni Malek, general manager of e-Ride Europe. **Telematics Japan 2009** will be held October 21–22 in Tokyo Bay Area, Japan.

eNavigation 2009

November 17–18, 2009, Seattle, Washington
www.enavigation.org

eNavigation 2009 will focus on the user: from the individual mariner, to the fleet manager, to waterways and harbor authorities, to regulatory and environmental agencies. eNavigation 2009 provides the operations sector of the maritime community an opportunity to interact with regulators, policymakers and international organizations making and implementing AIS and eNavigation policy.

IGNSS2009 Symposium and Exhibition

December 1–3, 2009, Gold Coast, Australia
www.ignss.org/?D=16

Featured are keynote presentations from GNSS providers GPS, GLONASS, Compass, and Galileo, and presentations from international experts in key applications areas. A Working Group of the United Nations-mandated International Committee on GNSS (ICG) will also meet.

CERGAL 2010: International Symposium on Certification of GNSS Systems & Services

April 28–29, 2010, Rostock, Germany
www.dgon.de

Organized by the German Institute of Navigation and GZVB e.V. / GAUSS, CERGAL 2010 focuses on the qualification and certification for mission and safety-critical applications for satellite navigation systems such as GPS/EGNOS and Galileo.

See all events at www.gpsworld.com/events.