GPS-INS: from Geodesy to Physiology

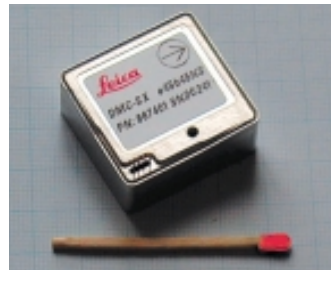
Would tri-axial accelerometers and indirect calorimetry bring new perspectives to Leica receiver GPS System 500 ? We believe so, since the combined utilization of such devices is of major interest in the world of applied physiology.

The appearance of new high sampling frequency receivers has opened the way to new GPS applications. If satellite positioning is nowadays very common for surveying tasks, its use to determine human walking pattern is very recent. Most of the studies about this topic have been up to now performed in a closed environment, far away from free-living conditions. Typical gait analysis is based on video recordings, which reduces the freedom of the subject and limits the study to a few strides. Consequently, many questions are still open about human locomotion outside the laboratory. Examples are the adaptation of stride length/ stride frequency and walking speed to the incline of terrain, stride-to-stride variability and walking pattern variation related to each individual. By performing in parallel gas exchange analysis (portable indirect calorimeter), data about energy expenditure can be also retrieved and hence walking efficiency as a function of speed (GPS) can be obtained. The common interest in on foot navigation has lead to a collaboration between the Geodetic Engineering Laboratory of the Swiss Federal Institute of Technology (EPFL), leaded by professor Bertrand Merminod, and the Applied Physiology Research Group of Dr. Yves Schutz from the University, both located in Lausanne (CH). Three PhD theses are actually related to this theme.

The study of human locomotion is not only important for physiologists, but also for geomaticians, concerned with navigation for people. As satellite signals are not always available (e.g. urban canyons, indoor activities),. there is a major interest in finding sensors capable of taking over when satellites are not available (Dead Reckoning). If the problem has been almost completely solved for vehicles using odometer and map matching, the solution for on foot navigation is far more complex.
Dead Reckoning for people is principally based on step count and azimuth of displacement. The number of steps is calculated using accelerometry, while the azimuth is obtained through the means of an electronic compass. After several experiences with separated instruments, all tests are performed now using a new high precision, all-in-one module. The DMC-SX is produced by the Defence & Special Projects (DSP) group of Leica Geosystems AG, and includes three magnetic field sensors and three accelerometers (which also are used as tilt sensors).
A close collaboration between the 3 partners, each one specialized in a particular, but complementary field, has the scope to develop appropriate algorithms to be implemented in a compact, ergonomic INS/GPS device. This appears to be a big challenge that can open the way to a wide range of civilian applications, as well as military ones.
So, on your mark.get set… WALK!

Quentin Ladetto, Vincent Gabaglio, Bertrand Merminod, Philippe Terrier, and Yves Schutz
http://dgrwww.epfl.ch/TOPO/

Quentin Ladetto, PhD student at the Geodetic Engineering Laboratory, during a test with the complete GPS-INS-Calorimeter equipment for parallel measurements of physiological and geodetic parameters. Quentin Ladetto walked five different runs at increasing walking speed. A clear correlation exists between body acceleration measured with portable accelerometer, walking speed measured with Leica GPS 500 in DGPS mode, and energy expenditure measured with portable indirect calorimeter. It is therefore possible to consider energy expenditure prediction by using either GPS speed or acceleration when satellites are not visible.



When Small is beautiful:"The DMC-SX of Leica that includes three magnetic field sensors, three accelerometers (which also are used as tilt sensors), temperature indicator and a Flash microprocessor.