
EXTREME MINIATURIZATION: SEVEN DEVICES, ONE CHIP TO NAVIGATE WITHOUT GPS

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The U.S. Military relies on the space-based Global Positioning System (GPS) to aid air, land and sea navigation. Like the **GPS units** in many automobiles today, a simple receiver and some processing power is all that is needed for accurate navigation. But, what if the GPS satellites suddenly became unavailable due to malfunction, enemy action or simple interference, such as driving into a tunnel? Unavailability of GPS would be inconvenient for drivers on the road, but could be disastrous for military missions. DARPA is working to protect against such a scenario, and an emerging solution is much smaller than the navigation instruments in today's defense systems.

DARPA researchers at the University of Michigan have made significant progress with a timing & inertial measurement unit (TIMU) that contains everything needed to aid navigation when GPS is temporarily unavailable. The single chip TIMU prototype contains a six axis IMU (three gyroscopes and three accelerometers) and integrates a highly-accurate **master clock** into a single miniature system, smaller than the size of a penny. This chip integrates breakthrough devices (clocks, gyroscopes and accelerometers), materials and designs from DARPA's **Micro-Technology for Positioning, Navigation and Timing (Micro-PNT) program**.

Three pieces of information are needed to navigate between known points 'A' and 'B' with precision: orientation, acceleration and time. This new chip integrates state-of-the-art devices that can measure all three simultaneously. This elegant design is accomplished through new fabrication processes in high-quality materials for multi-layered, packaged inertial sensors and a timing unit, all in a tiny 10 cubic millimeter package. Each of the six microfabricated layers of the TIMU is only 50 microns thick, approximately the thickness of a human hair. Each layer has a different function, akin to floors in a building.



“Both the structural layer of the sensors and the integrated package are made of silica,” said Andrei Shkel, DARPA program manager. “The hardness and the high-performance material properties of silica make it the material of choice for integrating all of these devices into a miniature package. The resulting TIMU is small enough and should be robust enough for applications (when GPS is unavailable or limited for a short period of time) such as personnel tracking, handheld navigation, small diameter munitions and small airborne platforms.”

The goal of the Micro-Technology for Positioning, Navigation and Timing (Micro-PNT) program is to develop technology for self-contained, chip-scale inertial navigation and precision guidance. Other recent breakthroughs from Micro-PNT include **new microfabrication methods and materials for inertial sensors**.

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