## Draper Laboratory's Role in MEMS and MCM Technology Development

Today there is a demand for electronic systems that are smaller and offer more functionality. To meet this demand, Draper continues to advance its multi chip module (MCM) and microelectromechanical systems (MEMS) capabilities, pushing the limits of these technologies. Leveraging the advances in semiconductor technology and integrated circuits (ICs), Draper has designed, built, and delivered some of the smallest, most highly advanced systems in the world. Draper's MCMs continue to integrate and pack additional functionality into smaller volumes. Through this integration, MCMs dramatically reduce the size and weight of complex electronic systems, thereby enabling entirely new capabilities.

Draper is expanding the functionality of its specialized tiny systems by integrating MEMS, which are miniature mechanical devices built using semiconductor manufacturing techniques. MEMS devices are approximately 1 to 100 micrometers in size – the average human hair is 50 micrometers in diameter. MEMS devices are ubiquitous—they can be found in gyroscopes, micro-fuel cells, optical fiber switches, fingerprint sensors, microphones and automotive applications. For example, when a car airbag senses rapid deceleration and fires, it's because of a MEMS accelerometer. These devices are small but absolutely vital.

MEMS are not only useful in industrial and consumer products, but are also finding biomedical applications. An emerging field of research, known as BioMEMS, is enabling the creation of smaller and more functional devices to improve medical diagnostics and therapies. BiOMEMS applications include diagnostic tools, surgical instruments, tissue repair, artificial organs, and drug delivery systems. BioMEMS technologies could address pressing global challenges ranging from the detection of infectious disease to the organ shortage.

Illustrating the enormous potential of BioMEMS, the Draper Laboratory is developing a number of implantable drug delivery devices. Draper researchers have proposed an implantable, fully programmable, mechanical device for long-term drug delivery to the eye wall, thus avoiding the risks of injection into the eyeball. An implantable ophthalmic drug delivery device could benefit those with macular degeneration. Draper researchers are also working to improve inner ear drug delivery and envision tiny implantable devices which could deliver drugs to the cochlea, part of the inner ear, and allow for the treatment of hearing loss and other auditory diseases.

Draper Laboratory's work has demonstrated that MCMs and MEMS – distinct classes of technology - can be wed together. During the 1990s, projects done for the Department of Defense in precision guided munitions illustrated the effectiveness of combining low-cost MEMS inertial sensors with MCMs.

MCMs are classified by their substrates, or bases, which can be ceramic, dielectric, silicon or a laminated circuit board. Combining a number of different circuit dies on a common substrate, MCMs have allowed for the integration of MEMS with microelectronics. Various MEMS sensors and actuators can be combined into a single package, forming complex systems that perform several functions.

Draper Laboratory's MCM technology has enabled the fabrication of electronic assemblies that are significantly smaller than high density surface mount versions. Draper develops the highest density multichip module circuit packaging technologies – including MCM-Laminate technology, MCM-Co-fire ceramic technology, and chips-first MCM-Ultra Thin Deposit technology – for a variety of application areas, including the space, military and medical markets.