BAE SYSTEMS

Frequently Asked Questions

Micro Autonomous Systems and Technology (MAST)

What capabilities will be derived from the MAST program?

The intent of the MAST program is to develop a wide range of mobile microsystems to increase warfighters' situational awareness by providing an extra set of eyes and ears. These micro systems will be equipped with a variety of sensors for navigation through complex urban environments and to detect potential threats. These sensors may include imaging sensors; micro radars; acoustic, thermal, and magnetic sensors; and location, orientation, and other bio-inspired sensors that have yet to be developed.

How different will these miniature robots be from other robots?

These robots have the potential to be very small and will operate in urban environments and complex terrain such as mountains and caves and places too inaccessible or dangerous for humans. They also will be designed to operate autonomously as a group, whereas most mobile robots today operate by themselves and are not fully autonomous.

How big will they be?

A variety of mobile micro systems will be developed under the MAST program. These include fliers, crawlers, hoppers, and hoverers. In some cases we envision a single device that can fly and move on the ground to overcome obstacles such as buildings and caves. The size of the devices will vary as well, according to their capability and the level of miniaturization we can achieve under the program. In general, the devices are meant to be used by individual soldiers, so one can envision devices the size of one's hand or the size of a bee or dragonfly.

What is their operating range?

The operating ranges of the devices are yet to be determined. Since the devices are to be used by individual soldiers within the area of a few city blocks, an endurance of minutes to a few hours should be sufficient to support a single mission. However, these devices also will be used with larger robotic systems in which they will be deployed many miles away and operate autonomously.

When could they be in use?

We envision that the technologies that will enable these systems will be continuously developed throughout the program and that some technologies and devices could be in use within a year. More complex devices will take longer to develop. All of our researchers are nationally recognized leaders in their fields, and have many ongoing projects. This depth of expertise will speed the progress of the development of these technologies.

What impact will it have on other BAE Systems products in the future?

The technologies that will be developed under MAST will have wide-ranging impact on BAE Systems products in the future, not just in the areas of robotics. The complex systems integration research that is needed to develop these future systems has application to all BAE Systems products as we strive to make products smaller and less expensive and reduce power consumption. The sensor and autonomous behavior technology that will be developed

will serve our customers' growing needs for unmanned air and ground systems and will be a critical part of BAE Systems' future growth.

Where will you conduct research to develop these miniature robots? The research that we will be conducting on the MAST program will be primarily in the United States at labs across the country. We will work with various universities in the United States, as well as with two international groups of researchers from the University of Sydney and the University of Milan.

What will be the cost of developing a single robot?

Affordability is a key goal of the program. Although exact costs will not be known until these devices are developed to the point they can be manufactured, we envision their costs to be comparable to a cell phone or iPod in today's dollars.

Please share details on the areas of R&D that the MAST alliance is planning to venture into.

There are several key focus areas for the research:

- **Learn from nature** — for example, how does a bee find its way back to the same flower, and how does a gecko climb a vertical wall?
- **Collaborative behaviors** — for example, how do ant colonies and packs of wolves work cooperatively to accomplish tasks that no single entity can accomplish alone, how do they communicate, and how do they distribute work?
- **Multifunction integration** — for example, how does one design a robot with legs that also function as antennas, or whose body is also a battery?

These research areas are further focused on small-scale aeromechanics and ambulation; propulsion; sensing, processing and communications; navigation and control; micro devices and integration; platform packaging; and systems architecture.

What technologies will the future robotic systems use? How advanced will they be compared to the technologies in this space at present?

The key areas of technology that distinguish the MAST research from current technology are the extreme level of integration that will be required to make these devices a reality, the development of multi-function sensors and actuators, and micro power management.

For example, distributive sentience, or the ability to sense and understand on small-scale mobile robots, will be required of the collective group of robots. Individual micro robots will collect different kinds of data and share the information with others. One micro robot might utilize cameras, another might detect radio frequencies, and another might use acoustics. By integrating the different data and individual capabilities, the robots will create a fusion of knowledge of their environment.

Some of these technologies are in development, but only in laboratories and under benign environments. Our goal over the next five to 10 years is to mature the most promising technologies and develop potential solutions to challenges we encounter along the way. We can forecast a number of technologies that will need to be developed right now, but the biggest challenge will be those that we don't understand or have not yet encountered. This is

why we have included researchers from many disciplines who will work together to bridge these gaps.

Please elaborate on the intelligence-gathering aspect and what tasks will it empower the robots to do.

One of the fundamental tenets of the MAST program is that groups of micro systems operating collaboratively can overcome obstacles and perform missions impossible or impractical for any one robot. The development of autonomous and group behaviors is a critical topic for the research. This is one of the key areas we are looking at nature to teach us. Many species exhibit the type of complex group behaviors we seek, and our challenge is how to convert these behaviors into ones and zeros.

Is this R&D initiative also going to address the challenge of reducing the cost of production of robots?

While the cost of producing these devices is a focus of the program, the primary focus is the development of enabling technology to make these systems a reality. We believe that these devices will be able to be mass-produced with readily available materials, helping make them affordable.