Kindling an interest in saving lives

by Catherine E. Borsché

Houston Fire Department captains recently arrived at Johnson Space Center with a helmet in hand that had been burnt through in a fire. The firefighter who had worn the helmet was in the hospital suffering from severe burns.

These captains came to NASA with one specific purpose. They wanted to tap into NASA technology to prevent situations such as the one described from occurring again. In particular, the firefighters were most interested in utilizing the technology used in Space Shuttle thermal protection system tiles, which can withstand heat up to 2,000 degrees Fahrenheit, to improve firefighter suits.

The JSC Habitability and Environmental Office's Firefighter Suit and Gear Project Team answered the Houston Fire Department's appeal to help design a better firefighter suit. This suit, dubbed the Firefighters Integrated Modular Suit, was designed to solve three major issues that firefighters face when going into a burning building: insulation from the environmental heat of the fire, protection from metabolic heat problems (such as heat stroke), and an improved, longer-lasting air supply.

Firefighters work in one of the most extremely hazardous environments known to humans. A typical house fire can reach 2,000 degrees Fahrenheit after just five minutes of flame, becoming lethal in a matter of seconds. In the current firefighter suit, a firefighter crawling on the floor of a burning building can withstand temperatures of 200–300 degrees Fahrenheit for about 30 minutes. This firefighter also has an air supply that can last up to 30 minutes. However, one of the most dangerous influences on a firefighter's ability to work is the firefighter's own core body heat. Half the firefighters who die each year are killed from metabolic heat problems and not the fire itself. If a firefighter is working hard and burning calories at a rate of 500 calories per hour, that firefighter's internal temperature can rise to dangerous levels. The firefighter's own body becomes the enemy by killing off cells – and eventually, causing a heat stroke.

"The situation that the burnt firefighter was in is what's called 'flashover,'" Theodore "Tico" Foley, JSC human factors analyst, said. "Basically, what happens is that you have a fire going on inside one wall, and it gets so hot that the radiant heat from that wall ignites the opposite wall and all the smoke and combustibles in between. Immediately, the temperature rises from approximately 500 degrees to 1,500–2,000 degrees – just in a flash."

NASA/DeHoyos JSC2004E43787

Human Factors Analyst Theodore "Tico" Foley is shown wearing the Firefighters Integrated Modular Suit with its breathing and cooling apparatus. The suit was designed by the Firefighter Suit and Gear Project Team to demonstrate how advanced technology already used for spacesuits can provide better protection for firefighters.

The Firefighter Suit and Gear Project Team went to work to search for better materials and technology to give firefighters the optimum equipment to survive such dangerous scenarios.

"With the current firefighter suit prototypes that we have right now, we use a combination breathing and cooling device. So, instead of taking compressed air on the backpack, the inventor who had worked on the Apollo Program realized that you could use cryogenic, supercritical air," Foley said. "That's what we use on the Shuttle right now for air resupply."

The advantage of utilizing this technology is that firefighters can take an oxygen and nitrogen air ratio and put it into one container. By keeping the air so cold and at a lower pressure, twice the amount of air can fit into a smaller bottle at a lower weight.

"The whole concept comes from NASA and was just miniaturized and put on someone's back," Foley said.

To address the firefighters' metabolic heat concerns, the Firefighter Suit and Gear Project Team integrated a cooling garment into the prototype suit that is virtually identical to the garment used in spacewalk spacesuits.

"It's basically just long johns with tubes of water or antifreeze of some sort going through it," Foley said. "You have two loops: the air loop, providing the cooling, and the water loop, which takes the heat from the body and exchanges it in the heat exchanger. You're not mixing the air with water, but you're passing it through, (similar to what) would happen with a radiator in a car."

By using supercritical, cryogenic air and a cooling garment, two of the issues are solved in creating a better firefighter suit. The firefighter has double the amount of air and a system to provide metabolic cooling.

The Firefighters Integrated Modular Suit also includes tailoring concepts taken from the spacewalk spacesuit.

"We've put in gussets and balloon joints so that we have more mobility. For example, if I raise my hands to fight a fire, the hem does not expose my wrists," Foley said. "We would also like to take the joints that we have for shoulders and elbows and miniaturize (them) for the firefighter's glove to give it greater movement and dexterity."

For this concept to be integrated and put into use, the concept firefighter suit would need to pass many levels of certification. Even though it has currently only passed a few levels of certification, there is an immediate application potential for using the suits here at NASA on the ground. The suits can be used for training and for the future development of advanced spacesuits.

"People are interested in seeing how this technology will emerge," Foley said. "With alterations, an inventor has the means available to him to develop suits that can be applied to lunar planetary surfaces using the same types of concepts. There are many direct applications for this technology to help us here at NASA, as well as the lifesaving and productivity capability for firefighters and first responders."

"I think it's an excellent program. This is certainly a benefit to NASA, too, in a sense that the public can see how our technology has benefited this country," John Jackson, human factors engineer, said. "It has a lot of implications in the firefighting world. The motivation is to help save lives."

NASA's Desert 'RATS' test new gear

NASA/Markowitz JSC2004E39642

by Kelly Humphries

ARIZONA'S HIGH DESERT isn't quite as tough on equipment as the Moon or Mars, but few places on Earth can give prototype spacesuits, rovers and science gear a better workout.

A NASA-led team headed for sites near Flagstaff, Ariz. in September to test innovative equipment. Engineers and scientists lead the Desert Research and Technology Studies (RATS) team from Johnson Space Center and Glenn Research Center. The team includes members from NASA centers, universities and private industry. Their efforts may help America pursue the Vision for Space Exploration to return to the Moon and travel beyond.

The sand, grit, dust, rough terrain and extreme temperature swings of the desert are attractive, simulating some of the conditions that may be encountered on the Moon or Mars. Crews wearing prototype advanced spacesuits are using and evaluating the new equipment for two weeks during September.

"For field testing, the desert may be the closest place on Earth to Mars, and it provides valuable hands-on experience," said Joe Kosmo, JSC senior project engineer for the experiments. "This work will focus on the human and robotic interaction we'll need for future lunar and planetary exploration, and it will let us evaluate new developments in engineering, science and operations," he said.

The team conducted a series of live satellite link videoconferences between researchers in the field and students at eight NASA Explorer Schools.

The 2004 Desert-RATS team includes participants from NASA's Ames Research Center, the NASA Research and Education Network team, Oceaneering Inc., Hamilton Sundstrand Inc., ILC/Dover Inc., the University of Cincinnati, the University of Maryland and Worchester Polytechnic Institute.

NASA/Markowitz JSC2004E39661

NASA/Markowitz JSC2004E39660

The Desert Research and Technology Studies team members put their technology through its paces in preparation for the testing in Arizona. From left to right: Chuck Beckman, Jessie Zapata, Dean Eppler (in suit), Nathan Smith, Edward Ehlers, Craig Bernard, Amy Ross, Barbara Janoiko, Bill Welch. Sitting: Joe Kosmo, Kevin Groneman.

Engineers in the Exploration Planning and Operations Center at JSC are providing mission control-type monitoring of the field tests.

The test equipment includes:

- New spacesuit helmet-mounted speakers and microphones for communications
- A "field assistant" electric tractor that can follow test subjects in spacesuits. It is guided by spacesuit-mounted controls
- A wireless network for use on other planets that can relay data and messages among spacewalkers, robots and rovers as they explore the surface
- A two-wheeled chariot that could be pulled by the electric tractor to carry astronauts
- "Matilda," an autonomous robotic support vehicle that can retrieve geologic samples
- Analytical equipment mounted on two mobile geology labs