

tion with matter and solution of the Boltzmann transport equation by use of both theoretical and numerical models. The biophysical models of breakage of DNA by radiation include biopolymer coarse-grained and atomistic models of DNA, stochastic-process models of deposition of en-

ergy, and Markov-based probabilistic models of placement of double-strand breaks in DNA. The program is designed for use in the NT, 95, 98, 2000, ME, and XP variants of the Windows operating system.

*This program was written by Frances A. Cucinotta of Johnson Space Center and Artem*

*Lvovich Ponomarev of Universities Space Research Association. Further information is contained in a TSP (see page 1).*

*Universities Space Research Association has requested permission to assert copyright for the software code. MSC-23853-1*

## On-Demand Urine Analyzer

*John H. Glenn Research Center, Cleveland, Ohio*

A lab-on-a-chip was developed that is capable of extracting biochemical indicators from urine samples and generating their surface-enhanced Raman spectra (SERS) so that the indicators can be quantified and identified. The development was motivated by the need to monitor and assess the effects of extended weightlessness, which include space motion sickness and loss of bone and muscle mass. The results may lead to developments of effective exercise

programs and drug regimes that would maintain astronaut health.

The analyzer containing the lab-on-a-chip includes materials to extract 3-methylhistidine (a muscle-loss indicator) and Risedronate (a bone-loss indicator) from the urine sample and detect them at the required concentrations using a Raman analyzer. The lab-on-a-chip has both an extractive material and a SERS-active material. The analyzer could be used to monitor the

onset of diseases, such as osteoporosis.

*This work was done by Stuart Farquharson, Frank Inscore, and Chetan Shende of Real-Time Analyzers, Inc. for Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18258-1.*

## More-Realistic Digital Modeling of a Human Body

*Lyndon B. Johnson Space Center, Houston, Texas*

A MATLAB computer program has been written to enable improved (relative to an older program) modeling of a human body for purposes of designing space suits and other hardware with which an astronaut must interact. The older program implements a kinematic

model based on traditional anthropometric measurements that do provide important volume and surface information. The present program generates a three-dimensional (3D) whole-body model from 3D body-scan data. The program utilizes thin-plate spline theory to

reposition the model without need for additional scans.

*This program was written by Renee Rogge of Mercer University for Johnson Space Center. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809. MSC-24040-1*

## Advanced Liquid-Cooling Garment Using Highly Thermally Conductive Sheets

**This garment provides metabolic heat rejection applicable to surgical cooling vests, combat fatigues, and firefighter and hazmat suits.**

*Lyndon B. Johnson Space Center, Houston, Texas*

This design of the liquid-cooling garment for NASA spacesuits allows the suit to remove metabolic heat from the human body more effectively, thereby increasing comfort and performance while reducing system mass. The garment is also more flexible, with fewer restrictions on body motion, and more effectively transfers thermal energy from the crewmember's body to the external cool-

ing unit. This improves the garment's performance in terms of the maximum environment temperature in which it can keep a crewmember comfortable.

The garment uses flexible, highly thermally conductive sheet material (such as graphite), coupled with cooling water lines of improved thermal conductivity to transfer the thermal energy from the body to the liquid cooling lines

more effectively. The conductive sheets can be layered differently, depending upon the heat loads, in order to provide flexibility, exceptional in-plane heat transfer, and good through-plane heat transfer. A metal foil, most likely aluminum, can be put between the graphite sheets and the external heat source/sink in order to both maximize through-plane heat transfer at the con-

tact points, and to serve as a protection to the highly conductive sheets. Use of a wicking layer draws excess sweat away from the crewmember's skin and the use of an outer elastic fabric ensures good thermal contact of the highly conductive underlayers with the skin.

This allows the current state of the art to be improved by having cooling lines that can be more widely spaced to im-

prove suit flexibility and to reduce weight. Also, cooling liquid does not have to be as cold to achieve the same level of cooling. Specific areas on the human body can easily be targeted for greater or lesser cooling to match human physiology; a warmer external environment can be tolerated, and spatial uniformity of the cooling garment can be improved to reduce vasoconstriction limits.

Elements of this innovation can be applied to other embodiments to provide effective heat transfer over a flexible and surface-conformable fashion without the limitation of fluid freeze points.

*This work was done by Warren P. Ruetemele, Grant C. Bue, and Evelyne Orndoff of Johnson Space Center and Henry Tang of Muniz Engineering. Further information is contained in a TSP (see page 1). MSC-24189-1*