COVER SHEET FOR GRANT PROPOSALS

State Board of Education

SBOE PROPOSAL NUMBER: (to be assigned by SBOE)	AMOUNT REQUESTED: $49,382.04
TITLE OF PROPOSED PROJECT: Biological Testing with MSM Micropumps	
SPECIFIC PROJECT FOCUS: **Research and Development**	
PROJECT START DATE: **February 18, 2011**	PROJECT END DATE: **June 30, 2011**
NAME OF INSTITUTION: **Boise State University**	DEPARTMENT: **Biological Sciences**
ADDRESS:	

Office of Sponsored Programs, 1910 University Drive, Boise, ID 83725-1135	E-MAIL ADDRESS: **osp@boisestate.edu**	PI PHONE NUMBER: **208-426-1514**

	NAME:	TITLE:	SIGNATURE:
PROJECT DIRECTOR	**Dr. Greg Hampikian**	**Professor**	[signature]
CO-PRINCIPAL INVESTIGATOR	**Dr. Peter Mullner**	**Professor**	[signature]

	NAME:	SIGNATURE:
Authorized Organizational Representative		
Office of Sponsored Programs	**Karen Henry**	[signature] 12/13/10
	Mary Givens	

Mark Rudin [signature]

SUMMARY PROPOSAL BUDGET

Name of Institution: **Boise State University**
Name of Project Director: **Dr. Greg Hampikian**

A. FACULTY AND STAFF

Name/ Title	Rate of Pay	No. of Months CAL	ACA	SUM	Dollar Amount Requested
Dr. Greg Hampikian/ Professor					**$0**
Dr. Peter Mullner / Professor					**$0**
% OF TOTAL BUDGET:	**0%**			**SUBTOTAL:**	**$0.00**

B. VISITING PROFESSORS

Name/ Title	Rate of Pay	No. of Months CAL	ACA	SUM	Dollar Amount Requested
Dr. Kari Ullakko / Visiting Research Professor	**$90,012**	**3.4**			**$25,692**
% OF TOTAL BUDGET:	**52%**			**SUBTOTAL:**	**$25,692**

C. POST DOCTORAL ASSOCIATES / OTHER PROFESSIONALS

Name/ Title	Rate of Pay	No. of Months CAL	ACA	SUM	Dollar Amount Requested
% OF TOTAL BUDGET:	**0%**			**SUBTOTAL:**	**$0.00**

D. GRADUATE / UNDERGRADUATE STUDENTS

Name/ Title	Rate of Pay	No. of Months CAL	ACA	SUM	Dollar Amount Requested
Undergraduate Research Assistant					**$4,000**
% OF TOTAL BUDGET:	**8%**			**SUBTOTAL:**	**$4,000**

E. FRINGE BENEFITS Rate of Pay (%)	Salary Base	Dollar Amount Requested
Dr. Kari Ullakko (29% of salary)	**$25,692**	**$7,449**
Undergraduate student		**$240**
	SUBTOTAL:	**$7,690**

F. EQUIPMENT: (List each item with a cost in excess of $1000.00.) Item/Description	Dollar Amount Requested
SUBTOTAL:	**$0.00**

G. TRAVEL: Dates of Travel (from/to)	No. of Persons	Total Days	Transportation	Lodging	Per Diem	Dollar Amount Requested
June 1-7, 2011	2	6	1200	400	400	$2,000
					SUBTOTAL:	**$2,000**

H. Participant Support Costs:	Dollar Amount Requested
1. Stipends	
2. Travel (other than listed in section G)	
3. Subsistence	
4. Other:	
SUBTOTAL:	0

I. Other Direct Costs:	Dollar Amount Requested
1. Materials and Supplies	$5,000
2. Publication Costs/Page Charges	
3. Consultant Services (Include Travel Expenses)	
4. Computer Services	
5. Subcontracts	
6. Other (specify nature & breakdown if over $1000) **Usage Fees for the Boise State Center for Materials Characterization $3,000** **Microfabriaction costs $2000**	$5,000
SUBTOTAL:	$10,000
J. Total Costs: (Add subtotals, sections A through I) **TOTAL:**	$49,382
K. Amount Requested: **TOTAL:**	$49,382

Project Director's Signature: [signature]	Date: 12/3/10

INSTITUTIONAL AND OTHER SECTOR SUPPORT

(add additional pages as necessary)

A. INSTITUTIONAL / OTHER SECTOR DOLLARS

Source / Description	Amount

B. FACULTY / STAFF POSITIONS

Description

C. CAPITAL EQUIPMENT

Description

D. FACILITIES & INSTRUMENTATION

Description

~~Dr. Kari Ullakko~~

HERC Budget

Budget Categories	%	Mths	Yr 1 Feb 18-June 30, 2011	Total Costs		Annual	per PP
Salaries							
Dr. Greg Hamplikian							
Dr. Kari Ullakko - 2/3 time Feb 18-May 17 (6.3 pp)	0.16	1.95	14,613.10	14,613.10		90012	3462
Dr. Kari Ullakko - full time May 18-June 30 (3.2 pp)	0.12	1.48	11,078.40	11,078.40		90012	3462
Undergraduate Research Assistant (AY & summer)			4,000.00	4,000.00			
Total Salaries			**29,691.50**	**29,691.50**			
Fringe Benefits		%					
Dr. Kari Ullakko - 2/3 time Feb 18-May 17 (6.3 pp)		0.29	4,237.80	4,237.80			
Dr. Kari Ullakko - full time May 18-June 30 (3.2 pp)		0.29	3,212.74	3,212.74			
Undergraduate Research Assistant (AY & summer)		0.06	240.00	240.00			
Total Fringe			**7,690.54**	**7,690.54**			
O&E							
Materials and Equipment < $5,000			5,000.00	5,000.00			
Fabrication services			2,000.00	2,000.00			
Characterization			3,000.00	3,000.00			
Total O&E			**10,000.00**	**10,000.00**			
Travel							
Meeting vendors of fabrication services			2,000.00	2,000.00			
			0.00	0.00			
Total Travel			**2,000.00**	**2,000.00**			
Student Costs							
Graduate Student Fee Remission			0.00	0.00			
Total Student Costs			**0.00**	**0.00**			
Capital							
			0.00	0.00			
Total Capital			**0.00**	**0.00**			
Total Direct Costs			49,382.04	49,382.04			
Base for Indirect Calculation			49,382.04	49,382.04			
Indirect Costs (F&A) Not Allowed (State Appropriation)			0.00	0.00			
Total Costs			49,382.04	49,382.04			

Budget Justification – Hampikian/Mullner/Ullakko SBOE HERC

Personnel
Principal Investigator Dr. Hampikian and Co-Principal Investigator Dr. Mullner will manage the project. No salary is requested.

Senior Personnel Dr. Ullakko will build a working MSM micropump suitable for incorporation into a device for biological testing. Funding request is 2/3 time for 3 calendar months and full time for 1.5 calendar months. Fringe costs for Dr. Ullakko are 29% of salary

Salary of $4,000 is requested for an undergraduate student who will assist Dr. Ullakko in the laboratory. The corresponding fringe is $240.

Operating Costs
The balance of the funding request is $5,000 for materials and supplies, $3,000 for usage fees for the Boise State Center for Materials Characterization, and $2,000 for fabrication services.

Travel
Funds of $2,000 are requested for meeting vendors of fabrication services.

Indirect Costs
Funding is from a State of Idaho appropriation from the State Board of Education, and indirect costs are not allowed.

PROPRIETARY INFORMATION DO NOT CIRCULATE

Biological Testing with MSM Micropumps

HERC PROPOSAL

PI Greg Hampikian, Co-PI Peter Mullner, research personnell Kari Ullakko

1. Executive Summary: Miniaturization of electronic components has revolutionized the field of sensors. However, building miniature pumps, the most mechanically demanding component of these devices, has proved difficult (figure 1). This proposal exploits a novel material that eliminates most of the mechanical elements in a micropump. Magnetic shape memory (MSM) elements are a new type of crystal that grows in relation to the surrounding magnetic field, thus providing the expansion and contraction required to move fluids and gases in sensing instruments. Our proposal combines the biotechnology and materials expertise at Boise State University, with the device development strengths of a pioneering Idaho company, Strategic Observation Systems Inc (SOS), and a leading US technology manufacturer, Lockheed Martin. SOS, with a base in Idaho, is working with the PI to develop a new generation of chemical sensing and reporting devices, and Lockheed Martin which has signed a NDA with the PI, is developing even smaller biosensors which require micropumps. The PI and co-PI's are preparing a patent application for a general principle of creating local shape changes in MSM material elements using local magnetic field pulses (thereafter as Patent). This Patent is expected to cover major part of the future micromechanical MSM applications in microfluidics, electronics and optics. We have also started a company Treasure Valley Technologies (TVT) Inc. in Boise to develop and manufacture MSM devices.

Bridge funds are requested to support the research scientist Kari Ullakko. Dr. Ullakko is working with the other PIs to develop more efficient micropumps that will be used in devices such as those made by SOS and Lockheed Martin, with initial applications in forensic DNA analysis and drug detection. All of these devices are being developed at BSU, or in collaboration with BSU researchers. Funding of this proposal will establish Idaho as a center of this important emerging technology. Taking into account the large commercial potential of MSM technology (over $20 billion USD/year), TVT, SOS, and their national partners, have the potential to grow into a remarkable employer in Idaho.

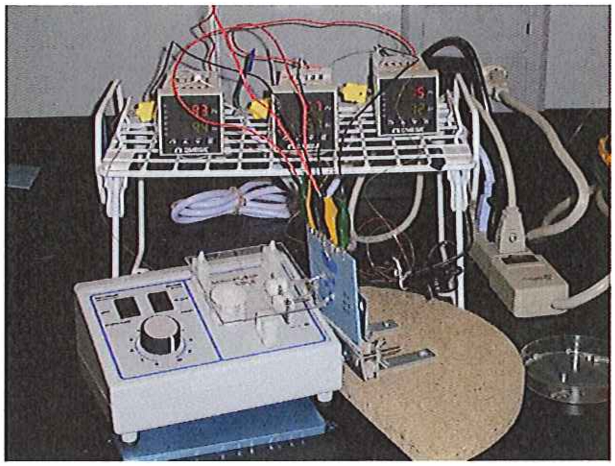


Figure 1. Miniature DNA Amplification and Bioterror Detection device designed by PI and collaborators in the College of Engineering at BSU (Moeller et al., 2007). The device is the small blue object in the center (about 4 inches square, 1/8 inch thick), the pump is the large white device in the left bottom of the image.

2. "Gap" Project Objective: Design and construct micropumps for biological testing based on MSM materials. **Total Amount Requested:** $49,383

3. Name of Idaho public institution: Boise State University

4. Name of faculty member directing project: Greg Hampikian, Ph.D.

5. Description of how resource commitments reflect the priorities of the home institution

In 2010, Boise State University began an accelerated program to further the expertise of BSU in MSM materials development, and to speed up technology transfer of biological applications of this material. Mary Givens the Director, Office of Technology Transfer at BSU, Hampikian (Professor of Biology) and Mullner (Professor of Materials Science and Engineering) each contributed funds from existing programs to bring Dr. Kari Ullakko from Finland to BSU. Dr. Ullakko discovered MSM materials while at MIT, and formed the world's fist MSM company. With Dr. Ullakko at Boise State, Idaho is now positioned to become a world leader in product design and production using MSM materials.

The University has dedicated significant resources to facilitate development and industrial partnerships to exploit this technology. Hampikian and Mullner joined the BSU faculty in 2004, and have a patent pending on power generation technology using MSM elements. Mullner has two further MSM-related patents with BSU. These patent applications and Dr. Hampikian's work in miniaturizing DNA amplification technology led to the industrial research collaborations which are at the heart of this proposal. The University has been working with Mullner and Hampikian to develop novel uses of MSM materials in biological pumps, power generation, electronic memory and other applications for the past five years.

This proposal would be the first corporate/BSU partnership to fund research aimed at solving a significant industrial problem using MSM technology developed at the university. The groundwork for this collaboration has been laid over the past year, with non-disclosure agreements and meetings between PI Hampikian and researchers from Lockheed Martin corporation, and SOS International. Both companies are developing miniaturized biological assays which require micropumps. SOS International has an alcohol sensing anklet (Fig. 2) used by law enforcement that is being currently being considered by Idaho law enforcement agencies, and Lockheed Marin has a forensic DNA profiling device that has been in development for two years and is near production. Bridge funding will allow this important work to continue until decisions are made in the latest round of proposals which can not begin until July 2011. After this project has ended Dr. Ullakko will start leading MSM product development at TVT.

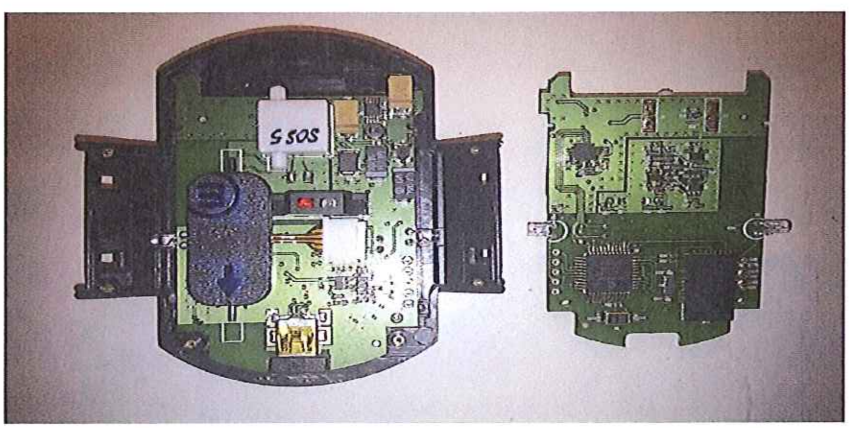


Figure 2. Inside of the SOS International alcohol sensor with GPS monitor. Component labeled M is the current pump which would be miniaturized by the MSM pump element being developed at BSU.

6. Evidence that the project will have a potential impact to the economy of Idaho

There are 4 million people in the US alone that are currently on probation, and a condition of nearly all people on probation is that they not consume drugs or alcohol. There are 1.5 million DUI arrests in the US per year, and there were nearly 12,000 alcohol related traffic deaths in 2009. Strategic Observation Systems Inc (SOS) headquartered in Meridian, Idaho, produces an alcohol sensor with GPS that requires a miniature pump.

SOS uses a piezoelectric based pump imported from Great Britain. TVT is a Boise based company formed to facilitate the transfer of technology from Universities to the private sector. This project proposes to complete the design of the MSM micro-pump at BSU, and for TVT to use the BSU design to manufacture commercial quantities of the MSM micropump. BSU would earn royalties, and manufacturing jobs would be added to Idaho.

The benefit to the State of Idaho is directly proportional to the number of micro-pumps sold. Approximately 10-20 jobs are expected within the first 2 years. In addition the production of MSM micropumps would establish the MSM industry in Idaho.MSM technology has reached the point where the basic science in understood well, and many products based on the technology are expected to enter the market in the next several decades. Employment in this industry is expected to follow the same pattern as the semiconductor industry of the 1960's and 1970's.

7. Establishes partnerships with the public or private sector or contribute to new company creation. This project will benefit 3 Idaho entities: Boise State University, SOS, and TVT. BSU will receive royalties from research done in their facilities. SOS is a 15 person firm in Meridian that will use this pump to improve their product and achieve market share gains. TVT is a recently formed company that has no employees except the founders, but we envision the micropump as the product that will launch the firm. This project will also be the first collaboration between SOS and TVT. Theses 2 Idaho companies have complementary competences, and this project could lead TVT and SOS to collaborate on other new products, i.e. on-site DNA analysis.

8. The Market Opportunity: Transdermal alcohol sensors are a fairly small market with an estimated 90,000 units in use today. This number is expected to climb as public sector budget constraints pressure officials to depopulate prisons. In 2006 there were more than 1 million arrests in the United States for DUI of Alcohol. There have also been a number of requests from parents to fit their teenage children with the sensors as a way to prevent teen DUI. Given these statistics an ultimate market size of 300,000 micropumps for alcohol sensors is reasonable. There is currently only one player in this field, SCRAM by AMS. Their website claims that they have monitored 120,000 offenders regarding alcohol consumption/detection.

The alcohol sensor micropump is envisioned as the first in a family of micropumps. Rapid on-site DNA analysis requires only a micro-pump to become a reality, which is the basis of our collaboration with Lockheed Martin. The applications for this technology are manifold within forensics, bio-terror, food safety, and medical diagnostics as a few examples. Markets for these products do not exist today, so all estimates for market size rely on extrapolation from a limited set of data. However, a market size of 1,000,000 units is conservative.

The overall annual sales potential of the MSM materials is expected to be around $20 billion (about the current level of piezo devices).

9. The Technology: Magnetic shape memory (MSM) alloys are multi-functional materials exhibiting coupling between magnetic and structural order which leads to a very large changes in length. The MSM effect arises through the magnetic-field-induced motion of twin boundaries [2; 3]. While the magnetic shape-memory effect is useful for actuation purposes, the inverse effect may be utilized for sensing and energy harvesting applications [4]. Compared to other technologies MSM actuators offer several benefits:

- Up to 100 times longer stroke than piezo materials (stroke up to 10 %)
- Fast response (even 0.1 millisecond)
- Large work output (100 kJ/m^3)
- High position accuracy (nanometers)

- Low power consumption
- Simple and reliable construction

Due to the 100 times larger strokes than competing materials, MSM has an advantage, which is expected to lead to a "revolution" in mechanical engineering. MSM materials can perform the same functions that have required the use of complicated electromechanical machines with mechanical gears and shafts, etc. Thus, MSM materials will make motion-generating products cheaper, smaller, simpler, faster and more accurately controlled.

MSM materials will be applied in many fields of engineering. They are expected to replace solenoids and other electromechanical devices, pneumatics and hydraulics in applications that require high response times and simple construction.

How does the technology contribute to the product and market need and its intellectual property status? MSM materials are a unique solution for micropumps and other microdevices. The shape changes of the MSM elements generated by a magnetic field source that is placed outside the fluid channel (hermetically isolated from the fluid) pumps the fluid. The whole pump is just a piece of MSM material. This simple construction makes MSM pumps small in size, reliable and low cost. The large strokes of MSM elements (up to 10 %), high positioning accuracy (nanometers) , and high response time (even 0.1 ms) is a combination that cannot be achieved by any other technology. This makes it possible to make micropumps that deliver fluids even in nanolitres quantities at a speed of meters per second. The same pump can transfer large volumes of fluids several milliliters per second. No other technology has this variety of properties which are ideal for micropumps. Micropumps are needed in many fields of biomedical and chemical industry and in engineering. In this project we target in two biomedical applications. The applicants have made recently a remarkable invention (hereafter as Invention) of configuring twin structures by local magnetic fields. We will soon propose BSU to apply provisional patent application for the Invention. This Invention makes it possible to develop microfluidic pumps, manifolds, valves and optical devices.

Who developed the technology and with what funding? Dr. Ullakko invented the MSM effect and reduced it to practice at MIT in 1996. That project was funded by Technology Development Agency of Finland. Since then Dr. Ullakko has developed MSM materials and devices in different projects in Finland, the European Commission and ONR with total investment of about $15 million. Dr. Mullner is one of the world's leading MSM scientists. He has developed MSM technology projects for over 12 years. Dr. Mullner currently has 15 students and researchers in his MSM group at Boise State University sponsored by several Federal agencies. Dr. Ullakko's current research at BSU is funded by the Department of Energy, Office of Basic Energy Sciences. Dr. Hampikian's DNA amplification device (Fig. 1) was funded by grants from the Environmental Protection Agency, and Department of Defense.

Theoretical soundness of the project: The invention makes use of the fact that twin microstructures can be reorganized locally. Shear is transmitted on different length scales via the motion of disclination dipoles, which are equivalent to a dislocation, and thus carry a Burgers vector. On the smallest length scale, the individual twinning disconnection, the Burgers vector is given by the lattice. On the next length scale, i.e. an individual primary twin, the Burgers vector is proportional to the twinning shear and the twin thickness. On the third length scale, the Burgers vector is proportional to the twinning shear, the twin thickness, and the difference of internal twin fraction. Thus, the larger the length scale, the greater is the flexibility to accommodate different shear values. Also the Burgers vector of a disconnection is limited to values imposed by the lattice (or the symmetry elements of an interface). Disclination dipoles have equivalent Burgers vectors that are not limited to the same set of values.

Maturity of science/technology: The PIs have applied for three patents with BSU on MSM technology, and the pump will be the first commercial application of their combined efforts. Dr. Hampikian is leading the pump development efforts, while Dr. Mullner's group continues to develop the MSM element manufacturing chain. We are on target for TVT to start building its pilot production line for MSM elements later this year.

Hardware development and integration risk: The hardware of the pump will be made using the silicon lithography technology with which MEMS devices are currently made. Coils will be made using similar lithography technologies. Attaching the MSM element into the silicon pump is straightforward, and does not include integration risks.The only challenge is the high dimensional accuracy requirements for preventing leaking of the fluid.

Maturity of the system: At Boise State University we have developed an MSM pump demonstrator on the "milli scale", and manufacturing technology for MSM single crystals and elements. Figure 3 (left) shows the base part of the MSM pump. The longest dimension of the pump is 30 mm. This pump was designed to pump 1 millilitre per second with a dozing accuracy of 30 nanolitres.

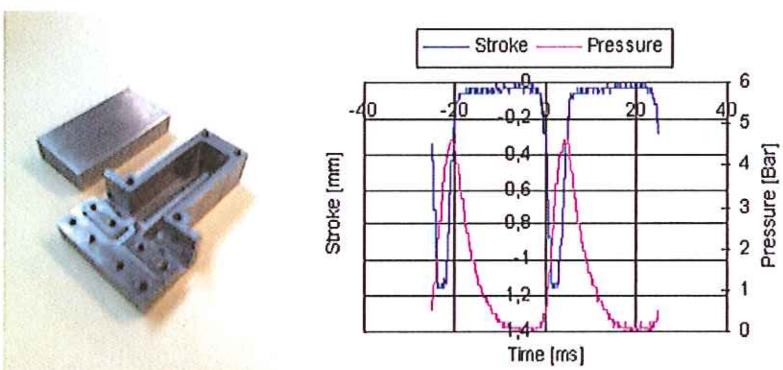


Fig. 3. (left) Base part of the MSM pump made in BSU, (right) Stroke of the valve, and pressure behind the valve as a function of time [5].

Figure 3 (right) shows the high speed of the MSM actuator in an example fluid valve. The stroke of the actuator (blue line) closes the valve and increases the pressure (red line) behind the valve in 4 milliseconds. The MSM pumping principle has been proven in our lab.

Viability of the technology: The current technology is fully viable in the laboratory scale, funding is sought to reduce it to industrial requirements.

10. Commercialization Partners Dr. Greg Hampikian is a professor of biology and criminal justice at BSU, and he is a founder of Treasure Valley Technology. Dr. Peter Mullner is a professor of material science at BSU, and a consultant to TVT. TVT was formed to move MSM technology from the laboratory to the market. Successful completion of this project will be the creation of an MSM micro-pump prototype. The first step after the prototype is completed is to fit it inside of the alcohol monitor developed by SOS. In addition to SOS there are a number of companies that have expressed an interest in deploying MSM micro-pumps in their products. Lockheed Martin is one such company. Once the micro-pump prototype is made, it will be demonstrated to Lockheed and adapted to their needs. The third step is to assemble a working prototype for on-site DNA analysis using the micro-pump and existing technology. TVT will then leverage its existing relationships with law enforcement, the U.S. Department of Defense, and the food safety industry to market the DNA analyzer.

11. Specific Project Plan and Detailed Use of Funds with Timeline

- **Task 1 February to March:** Design the pump according to specifications.
- **Task 2 March to April:** Make the MSM element and test its performance:
- **Task 3 April to May:** Make pump from silicon by a subcontractor according to our design.
- **Task 4 May to July:** Assemble and test the pump with SOSI alcohol sensor.

Personnel: Dr. Ullakko will build a working MSM micropump suitable for incorporation into a device for biological testing; funding request is 2/3 time for 3 calendar months and full time for 1.5 calendar months. Salary of $4,000 is also requested for an undergraduate assistant with design experience who will work on computer drawing, modeling, MSM element preparation, and assembly of the devices. Due to the compressed time period for the proposed work, if personnel modifications are needed they will be made in consultation with the PI and Office of Technology Transfer.

Operating Costs: The balance of the funding request is $5,000 for materials and supplies,

$3,000 for usage fees for the Boise State Center for Materials Characterization, and $2,000 for fabrication services. **Travel** $2,000 is requested for meeting vendors of fabrication services.

12. Education and Outreach: In addition to the hired undergraduate student, other graduate and undergraduate student researchers in Hampikian and Mullner's laboratories will be involved in research components of the biological device design, and MSM element development. In addition, the PIs and Dr. Ullakko will present their results to the Idaho entrepreneurial community though Kickstand and TechConnect. Dr. Hampikian also meets with school groups each month to show Idaho school children the wonders of research. Dr. Ullakko will also present his work during the seminar series in the College of Engineering at BSU.

13. Institutional and Other Sector Support: BSU has ardently supported this work through the Office of Technology Transfer. Mary Givens, the Director of the office has worked with Drs. Hampikian and Mullner on MSM technology and biological testing for the past two years, and invested $20,000 of her discretional funds to support Dr. Ullakko's MSM work at BSU. She has also arranged meetings for the PIs with companies interested in their technology, and has been instrumental in bringing Lockheed Martin and SOSI on board. Ms. Givens also coordinated a group of MBA students who assessed the promise of MSM technology in a semester-long study which resulted in a business development plan that served as the launching point for TVT. Finally, the Office of Technology Transfer has shown its commitment to this project by paying for three separate MSM patent applications covering inventions by the PIs.

References

1) K. Moeller, J. Besecker, G. Hampikian, A. Moll, D. Plumlee, J. Youngsman and J.M. Hampikian, "A Prototype Continuous Flow Polymerase Chain Reaction LTCC Device," Materials Science Forum Vols. 539-543 (2007) pp. 523-528
2) K. Ullakko, J. K. Huang, C. Kantner and R. C. O'Handley, Large Magnetic-Field-Induced Strains in Ni2MnGa Single Crystals. *Applied Physics Letters*, Vol 69, 1996, p. 1966-1968.
3) J. Ma and I. Karaman, Expanding the Repertoire of Shape Memory Alloys. *Science*, Vol 327, 2010, p. 1468-1469.
4) A. Nespoli, S. Besseghini, S. Pittaccio, E. Villa and S. Viscuso, The high potential of shape memory alloys in developing miniature mechanical devices: A review on shape memory alloy mini-actuators. *Sensors and Actuators a-Physical*, Vol 158, 2010, p. 149-160.
5) I. Suorsa, J. Tellinen, E. Pagounis, I. Aaltio and K. Ullakko, Applications of Magnetic Shape Memory Alloys, Proc. of the Int. Conf. Actuator 2002, 10-12 June 2002, Bremen, Germany, p.158-161
6) P. Mullner and A. King, “Deformation of hierarchically twinned martensite” Acta Materialia 58 (2010) 5242-5261.

Appendices

Facilities and Equipment:

Biology: Hampikian Laboratory Facilities

The main Hampikian laboratory consists of approximately 800 square feet. The lab is equipped with: ABI 3130 Genetic Analyzer, ABI 310 Genetic Analyzer (shared with Dr. Kevice Ferris), LI-COR 3100 DNA sequencer with dedicated Optiplex GX280 computer, Qiagen BioRobot EZ-1 DNA processor, BioRad Gel Imager, Coulter Counter, NanoDrop spectrophotometer, Eppendorf Real Plex^4 real time PCR cycler, BioRad icycler, MJ Research Minicycler, 4°C and -20°C refrigerators and freezers, NuAire Class II biosafety cabinet, two NUAIRE CO_2 incubators, Beckman LS6500 liquid scintillation counter, BioRad electroporator, and assorted electrophoresis and centrifugation equipment.

A second lab space (80 square feet) is connected to the main lab and contains microscopy equipment including a Zeis fluorescent microscope with Spot RT3 Camera, and an Olympus stereo microscope.

A third space of approximately 90 square feet is being prepared as a post amplification room that will house the 3130, 310, and all thermocyclers. This is essential for forensic applications, in order to prevent contamination with amplified human DNA.

Additional shared resources: the Department of Biology has a number of shared instruments including an Sorvall High Speed Centrifuge, Beckman TL100 Ultracentrifuge, Omni GLH Tissue Homogenizer, Savant SC110A/UVS400 Concentrator/Vacuum System, a Gilson HPLC (including size exclusion and reverse phase chromatography), LC (ion exchange and affinity chromatography) 1-D and 2-D gel electrophoresis systems, protein electroelution system, temperature-controlled chromatography cabinet, and Isothermal microcalorimetry (Microcal), Agfa CP 1000 film processor, Gyromax 737 and 737R incubators, Beckman Coulter Epics XL model flow cytometer, Beckman scintillation counter, Ice machine, and autoclave. ABI 7300 and an I-Core Smart Cycler II Real-Time PCR thermocycler are available for real time quantitative PCR. A LI-COR Global IR2 4200 gel-based automated DNA sequencer, with 64-lane capacity, upgradeable to 96 lanes, housed within the 500 sq ft Sequencing Lab. Large scale sequencing is routinely done at the Molecular Core Facility at Idaho.

Engineering: Most of the equipment is available in the laboratories of the PIs, the Boise State Center for Materials Characterization (BSCMC, located in the College of Engineering http://coen.boisestate.edu/bscmc/index.htm), and the Idaho Mircrofabrication Laboratory (IML, located in the College of Engineering http://coen.boisestate.edu/IMFL/index.html).

The instruments in the laboratory of Dr. Müllner include

1. Induret casting furnace for the fabrication of sputter targets and ingots.
2. Single crystal growth furnace.
3. Tube furnaces (1200 °C).
4. Muffle furnace (1000 °C).
5. High-sensitive Vibrating Sample Magnetometer (VSM) -- ADE model 10 with maximum field 2 T and heating/cooling capabilities for the temperature range from -100 °C to 150 °C.
6. Mechanical test bench Zwick 1445 (Zwick, Ulm, 500 N load cell, displacement resolution 10 nm), equipped with a variable field magnet Multimag 2000 (Magnetic Solutions, Dublin, 2 T).
7. Dynamical magneto-mechanical testing device with constant magnetic field of 0.97 T, field rotation of up to 12,000 revolutions per minute, heating/colling between 10 °C and 50 °C.
8. High-precision wire saw.
9. Diamond saw.
10. Polishing equipment.
11. Multibeam optical system of k-Space for substrate curvature measurements for temperatures up to 1,100 °C. Separate temperature reading system "BandiT" for exact temperature reading up to 600 °C.
12. Electrochemistry for electroplating and electropolishing.
13. Pumping system to evacuate samples in a quartz glass tube and to flush the tube with inert gas such as argon.

Further instruments available at the College of Engineering

14. Sputter deposition system with co-sputter (2 targets) and reactive sputter capability.
15. Two AFM (Veeco Dimension 3100 Atomic Force Microscopy System and Veeco PicoForce Multimode Atomic Force Microscopy System) with dedicated software for analyzing phase, amplitude and height and MFM and nanoindenter functions. The system also includes harmonics imaging and in-situ heating-cooling capabilities.
16. Scanning electron microscope -- LEO 1430VP with energy-dispersive X-ray spectroscopy (EDS) capability, electron beam lithography (EBL), electron backscatter diffraction (EBSD).
17. Transmission electron microscope JEOL 2100 LaB_6, with scanning transmission electron microscopy capabilities, EDS, EELS, and magnetic domain imaging.
18. x-Ray diffractometer Bruker D8 Discover with variable temperature up to 1600°C, texture capabilities, thin film reflectometry, phase analysis, HiStar area detector, and scintillation detector.
19. Optical microscope -- Zeiss Axiovert 200 MAT with CCD camera and software.
20. Variable temperature probe station for electrical measurements between 5.5 K and 450 K.

21. Advanced electrical characterization systems (attoampere and microvolt resolution) -- Keithley 4200 Semiconductor Characterization System Keithley 595 Quasistatic Capacitance-Voltage Meter, HP 4284A LCR meter, Keithley 707A Ultra Low Current-High Frequency Solid State Switching Matrix (2-8X24 I/O cards), Agilent 81110A Pulse/Pattern Generator Unit (2 channels - frequency range up to 330MHz), Agilent Infiniium 54832D 1GHz 4 channel 4GSamples/s Mixed Signal Oscilloscope.

Biographical Sketches and Individual Support:

NAME	POSITION TITLE
Greg Hampikian, Ph.D.	**Professor, Dept. Biology, Boise State University**

INSTITUTION AND LOCATION	DEG.	YEAR (s)	FIELD OF STUDY
University of Connecticut, Storrs, CT	B.S.	1982	Biological Sciences
University of Connecticut, Storrs, CT	M.S.	1986	Genetics
University of Connecticut, Storrs, CT	Ph.D.	1990	Genetics

A- Positions and Honors

1983-84 Research Assistant, Dept. Pediatric Dermatology, Yale Univ. School of Medicine

1990-91 US NSF Postdoctoral Fellow, LaTrobe University, Melbourne, Australia (with Jennifer Graves)

1992 Postdoctoral Associate, Worcester Foundation for Experimental Biology, Worcester, MA (with William Crane)

1993-2004 Assistant, Associate, Full Professor, Dept. Natural Science, Clayton State Univ., Morrow, GA

1994-95 Visiting Scientist, Emory University & The Centers for Disease Control and Prevention (CDC) Atlanta, GA

1997-98 National Science Foundation ROA award. Research Faculty Member, Dept. of Biochemistry, Georgia Institute of Technology, Atlanta, GA

2005- Associate Professor 2005-2006, Full Professor 2007-, Dept. of Biology, Boise State University, Boise, ID

Other Experience and Professional Memberships

2004 Chair, Georgia Academic Advisory Committee for Biological Sciences

2008-2009 Member, presenter, International Society for Forensic Genetics

1999-2009 Member, American Society of Microbiologists: Editor for education Newsletter (1999-2002), Editor for image archives (1999-2003); Moderator of the Molecular Biology and Biotechnology Education Listserve (1999-2003)

2000-2009 Member, International Society for Computational Biology

B- Selected peer-reviewed publications (in chronological order)

1. F. Deak, Y. Kiss, K. Sparks, S. Argraves, **G. Hampikian** and P. Goetinck, 1986, "Amino acid sequence of chicken cartilage link protein from c-DNA clones," *Proc. Natl. Acad. Sci. USA* 83:3766-3770.

2. J. Foster, F. Brennan, **G. Hampikian**, P.N. Goodfellow, A. Sinclair, R. Lovell-Badge, L. Selwood, M. Renfree, D. Cooper and J. Graves (1992) "Evolution of sex determination and the Y chromosome: *SRY*-related sequences in marsupials," Nature 359: 531-33.

3. J. Graves, J. Foster, **G. Hampikian**, F. Brennan, 1993, "Sex-determination in marsupial mammals," in *Sex chromosomes and sex determining genes,*(Editors, K. Reed and J. Graves) Gordon and Breach, Melbourne.

4. M. Gaudette, **G. Hampikian**, V. Metelev, S. Agrawal and W. Crain, (1993) "Effect on embryos of phosphorothioate modified oligos. into pregnant mice," *Antisense Res. & Dev.,*3:391-397.

5. **G. Hampikian**, J. Graves, D. Cooper, "Sex-determination in the marsupial" in Molecular Genetics of Sex Determination, (Ed. S. Wachtel) Academic Press (1996).

6. P. Henderson, D. Jones, **G. Hampikian**, Y. Kan, and G. Schuster, "Long-distance charge transport in duplex DNA: The polaron-like hopping mechanism," *Proc Natl Acad Sci USA* (1999) 96(15) 8353-8358.

7. M. Crayton, C. Ladd , M. Sommer, **G. Hampikian**, L. Strausbaugh, An organizational model of transcription factor binding sites for a histone promoter in D. melanogaster, *In Silico* Biology 4, 0045 (2004).
8. K. Moeller, J. Besecker, **G. Hampikian**, A. Moll, D. Plumlee, J. Youngsman and J.M. Hampikian, "A Prototype Continuous Flow Polymerase Chain Reaction LTCC Device," Materials Science Forum Vols. 539-543 (2007) pp. 523-528.
9. **G. Hampikian** and Tim Andersen; Absent Sequences: Nullomers and Primes, Pacific Symposium on Biocomputing 12:355-366 (2007).
10. L. A. Lucia, L. Adamapoulos, Jason Montegna, **G. Hampikian**, D. S. Argryopoulos, J. Heitmann, "A Simple Method to Tune the Gross Antibacterial Activity of Cellulosic Biomaterials," Carbohydrate Polymers 69 (2007) 805–810.
11. A. Kanu, H. Hill, G. **Hampikian**, S. Brandt, "Ribonucleotide and Ribonucleoside Determination by Ambient Pressure Ion Mobility Spectrometry (IMS)," Analytica Chimica *Acta 658 (2010) 91–97.*
12. Bourland, W., VĎAČNÝ, P, Davis, M., and **Hampikian, G.**, Morphology, Morphometrics and Molecular Characterization of Bryophrya gemmea n.p. (Ciliophora, Colpodea): Implications for the Phylogeny and Evolutionary Scenario for the Formation of Oral Ciliature in Order Colpodida, *Journal of Eukaryotic Microbiology* (in press, 2010)
13. Davis, M., Novak, S., **Hampikian, G.**, Mitochondrial DNA analysis of an immigrant Basque population: loss of diversity due to founder effects, *American Journal of Physical Anthropology* (2010, in press).
14. Bullock, C., Jacob, R., McDougal, O., **Hampikian, G.**, Andersen, T., DockoMatic Automated Ligand Creation and Docking, *BMC Bioinformatics* (2010, in press).

C. Research Support

Current Support

"DNA Safeguard"
Role: PI Agency: Department of Defense ($3,200,000) 2007-2010
Specific Aims:
Aim 1: To identify and rank, rare and absent sequences in amino acid and nucleotide databases.
Aim 2: To develop unique DNA sequences tags to protect DNA samples from contamination.

Overlap: There is no overlap between this grant and any other grant.

Completed Research Support

"Capillary Electrophoresis",PI Equipemnt grant, National Science Foundation, ($21,500)	2005
"Biosensors: LTCC Devices to Detect Biowarfare and Biosafety agents," PI, EPA, ($109,000)	2005
"Li-Cor Sequencer," PI, Li-Cor corportation ($50,000)	2005
"Biosensors: PCR Detection of Biowarfare and Biosafety agents using Novel Material," PI, Agency: EPA ($22,000)	2004

Dr. Peter Müllner concentrated his early work on deformation-induced twinning, characterization of twin structures with transmission electron microscopy, and modeling twin structures and twin-twin interactions in terms of dislocations and disclinations [119-124]. In 1997, he directed his attention to magnetic shape-memory alloys and calculated the magnetic force on a twinning dislocation [21].

After joining the Institute of Applied Physics at ETH Zurich in 1998, Müllner pursued experimental research on magnetic shape-memory alloys and magnetoplasticity of intermetallics. There he constructed testing machines for static and dynamical magneto-mechanical experiments. In 2004, Dr. Müllner moved to Boise, Idaho, where he joined the Department of Materials Science and Engineering at Boise State University (BSU). ETH Zürich donated equipment, which Dr. Müllner had developed at ETH, to his lab in at Boise State University.

In 2007, Müllner started an NSF-supported collaboration with Dr. Dunand at Northwestern University on Ni-Mn-Ga foam. Large MFIS of 0.12% was demonstrated in foam with coarse pores and monomodal pore-size distribution [129]. More recently, the MFIS was increase to 8.7% by tailoring the foam architecture (Fig. 4(a), [118]). These results demonstrate that constraints – imposed by external gripping or by internal grain boundaries – play a critical role because they suppress twin boundary motion and magneto-mechanical properties of MSMA.

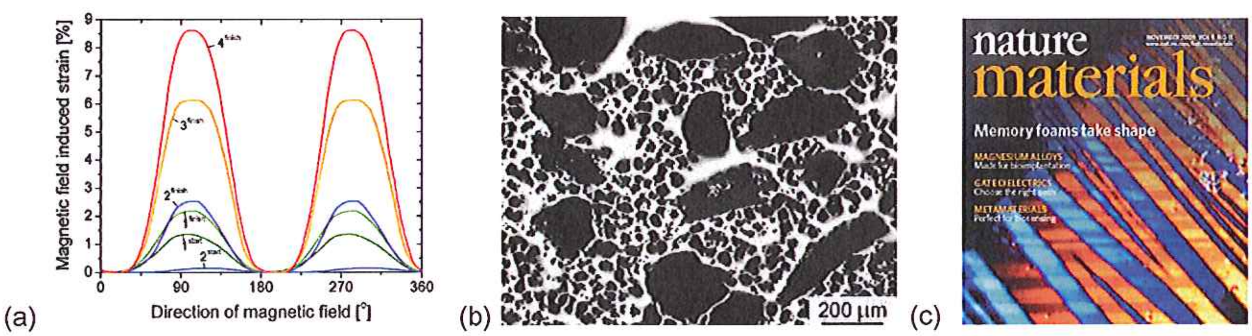
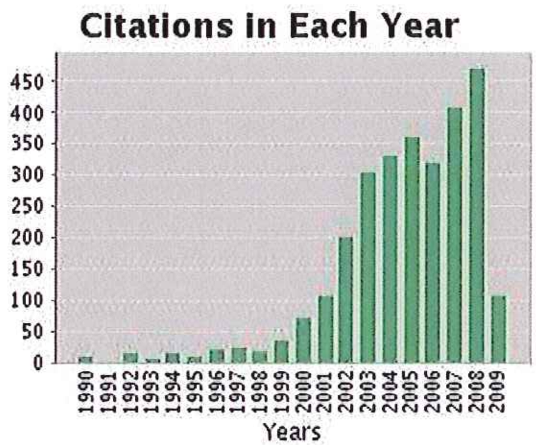


Figure 4: Ni-Mn-Ga foam with bimodal pore size distribution. (a) Magnetic-field-induced strain (MFIS) during one full rotation of a magnetic field of 0.97 T before and after the first four heating/cooling cycles. (b) Optical micrograph of a polished cross section showing two populations of pores (black) in Ni-Mn-Ga metal (white). (c) Optical micrograph with polarized light shows twins and decorates the cover of the November 2009 issue of Nature Materials [118].

By developing a cutting edge research laboratory focusing on the characterization of magnetic shape memory alloys, Dr. Peter Müllner has positioned himself among the leaders in the field. His research group grew quickly and currently has 15 members and his activities are spread worldwide through active collaborations with colleagues in Germany, Finland, Austria, Switzerland, Spain, Italy, China, Japan, and America. He gave more than 20 invited conference lectures and invited seminar presentations in the last three years. He has published 87 scientific publications (Hirsch index is 18 based on ISI Web of Science), and is the holder of one patent. He has three additional patents pending.

Examples of related research articles by key personnel (Dr. Peter Mullner):
Chmielus M., Mullner P. *et al.*, Nature Materials 8 (2009) 863-866.
Mullner P, *et al.*, Scripta Mater. 49, (2003) 129-133.
Chmielus M., Mullner P. *et al.*, Eur. Phys. J. Special Topics 158, 79-85 (2008).
Chmielus M., Mullner P. *et al.*, Acta Materialia, Acta Mater. 58 (2010) 3952-3962.

Dr. Kari Ullakko is a Visiting Research Professor in Boise State University. His current contract will end by January 11, 2011. Dr. Ullakko has worked in several university laboratories in different countries and led a number of development projects (Finnish, European Commission and US). Dr. Ullakko discovered the MSM effect in Ni-Mn-Ga in 1995 at MIT, and has studied and developed MSM materials and devices since then. He has been a research director and a president of high tech companies. In 1996 he started Adaptamat Ltd. (in Finland) to develop and commercialize MSM technology. Ullakko is a member of several advisory committees and professional organizations, and author or co-author of more than 220 publications, and a holder of 6 patents. One publication (Sozinov, Likhachev, Lanska, Ullakko, Appl. Phys. Lett. 80, 10, 2002) was selected in 2003 as the most fast breaking article in whole physics. The number of citations to his publications is over 3000, and the Hirsch index is 22 (i.e., 22 publications that have been cited at least 22 times). Figure 1 shows the number of citations as a function of time (According to Web of Science).



Graph at left shows the number of citations to Ullakko´s publications in recent years (as of March 2009).

Examples of related research articles by key personnel (Dr. Kari Ullakko):
Ullakko, *et al.*, Appl. Phys. Lett. 69, 13, 1996; (about 1000 citations)
Ullakko, J. Mater. Eng. and Performance, Vol 5 (3), pp. 405-409, June 1996; (1st MSM paper published).
Sozinov, Likhachev, Lanska, Ullakko, Appl. Phys. Lett. 80, 10, 2002; (most fast breaking article in Physics in 3rd quarter in 2003).
I. Suorsa, J. Tellinen, E. Pagounis, I. Aaltio and K. Ullakko, Applications of Magnetic Shape Memory Alloys, Proc. of the Int. Conf. Actuator 2002, 10-12 June 2002, Bremen, Germany, p.158-161
Straka, Lanska, Ullakko, Sozinov, Appl. Phys. Lett. 96, 2010, 131903

In summary, Dr. Ullakko and Dr. Müllner combined have 30 years of experience with magnetic shape memory alloys, including extensive experience with the Ni-Mn-Ga system, both in regard to material synthesis and material characterization. They are, thus, well prepared to perform the proposed study.

Provide documentation of other sector resource commitments.

SOS INTERNATIONAL

To whom it may concern: November 26, 2010

SOS International is an Idaho company headquartered in Meridian, Idaho. We develop, engineer and then market state of the art GPS tracking devices for law enforcement and judicial services, as well as for private companies and individuals. We have been working for the last 12 months on a transdermal alcohol sensing device which detects consumed alcohol in humans by sampling transdermal gases (perspiration). One of the key requirements for this technology is keep the overall package that is attached to a person's leg as small as possible. We are currently working with Dr. Greg Hampikian at Boise State University and several researchers there with regards to this emerging technology. The ultimate goal is to have the smallest micro pump possible inside of the device so that we can accurately sample these transdermal gases, evaluate what the sample contains, and then in real time send this data over cell phone frequency radios to the monitoring agency. Dr. Kari Ullakko of the Material Science and Engineering Department is working with our team on some key technology called Magnetic Shaped Memory (MSM) which when perfected will be the perfect solution for a high volume micro diaphragm pump which as I have mentioned is a critical part of our transdermal alcohol sensing technology.
I would highly recommend that the Higher Education Research Council (HERC) fund at whatever level possible the micropump design and MSM research being done by Hampikian, Ullakko and Mullner at Boise State University. Their successful completion of this technology is an essential step towards our future success in bringing the world the first micro real-time transdermal fuel cell alcohol sensor.

Best regards,

Paul Thomas
President—SOS International

BILATERAL NON-DISCLOSURE AGREEMENT
Boise State University
NDA No. 10-070-BG

This Agreement, effective as of the date of last signature of a party hereto, is made by and between **Lockheed Martin Corporation, acting by and through its Information Systems & Global Services business area** (hereinafter sometimes referred to as "IS&GS-Civil"), having a place of business at 700 North Frederick Ave., Gaithersburg, MD 20879 and **Boise State University** (hereinafter sometimes referred to as the "Company"), having a principal place of business at Biology 1910 University Drive Boise, ID, 83725-1515 and sets forth the terms and conditions for the protection, use and disclosure of confidential Proprietary Information by either Party to the other.

1. For purposes of this Agreement, IS&GS-Civil and the Company may be collectively referred to as the "Parties" or individually referred to as a "Party", "Disclosing Party", "Receiving Party" or "Recipient". For purposes of this Agreement the term "Affiliates" is that which is defined in Subpart 2.1 of the FAR. "Proprietary Information" shall include, but is not limited to, technical, business or financial information which: (a) is originated by or otherwise peculiarly within the knowledge of the one Party; (b) is currently protected against unrestricted disclosure to others; and (c) pertains to the Subject Program. "Subject Program" refers to data and information relating to the **Microfluidics**, and any and all task orders/follow-on work, if any, associated therewith.

2. In consideration for the disclosure of Proprietary Information, the Receiving Party agrees: (a) to hold Proprietary Information in trust and confidence and to only disclose or otherwise provide access to the same to those of its employees, directors, officers or consultants, ("Individuals") or its Affiliates with a bona fide need to know, provided that said Individuals or Affiliates have been made aware of their obligations hereunder, agree to be bound by the same and have entered into confidentiality agreements with its company which are no less restrictive than this one. In any event, the Receiving Party shall be responsible for the actions and inactions of its Individuals or Affiliates, and agrees, at its expense, to take all reasonable measures to restrain those Individuals or Affiliates from the unauthorized disclosure or use of the Proprietary Information; and (b) to refrain from using the same except for the purposes of Subject Program related proposal(s) and contractual effort, and all task order(s) associated therewith, if any, without prior approval of the Disclosing Party.

3. All financial information exchanged between the Parties is hereby deemed to be Proprietary Information and shall need no legend to be protected. All other Proprietary Information disclosed hereunder shall be protected under the terms of this Agreement: (a) if it is disclosed in writing, and is marked with the legend "PROPRIETARY INFORMATION" or an equivalent conspicuous legend; or (b) if it is disclosed orally or visually, and is identified as Proprietary at the time of disclosure and is subsequently reduced to a writing specifically identifying the items of a Proprietary nature and is furnished to Recipient within fifteen (15) days of disclosure; or (c) if it is disclosed by electronic transmission (e.g. facsimile, electronic mail, etc.) in either human readable form or machine readable form, and is marked electronically as proprietary within the electronic transmission, such marking to be displayed in readable form along with the any display of the Proprietary Information; or (d) if it is disclosed by delivery of an electronic storage medium or memory device itself as containing Proprietary Information and the storage medium or memory device itself is marked as containing Proprietary Information and such stored information is electronically marked as Proprietary Information.

4. A Recipient of Proprietary Information hereunder further agrees: (a) to preserve and protect such information for three (3) years from the date of disclosure; and (b) to exercise the same degree of care it uses to preserve and protect its own Proprietary Information and in no event shall less than a reasonable degree of care be utilized.

5. A Recipient of Proprietary Information hereunder will have no obligation or restriction and shall not be liable to a Party claiming a proprietary interest for disclosure of Proprietary Information if the same is: (a) in the public domain at the time of disclosure, or subsequently falls into the public domain without restriction through no wrongful act or omission on the part of the Receiving Party; (b) to the best of Recipient's knowledge, information and belief, lawfully known to the Receiving Party at the time of disclosure without restrictions on its use, as evidenced by competent proof; (c) independently developed by the Receiving Party, as evidenced by competent proof; (d) used or disclosed inadvertently or accidentally despite the exercise of the same degree of care, but not less than reasonable care, that each Party takes to preserve or safeguard its own Proprietary Information, provided Receiving Party notifies Disclosing Party forthwith and subsequently exerts reasonable efforts to prevent any further inadvertent or accidental disclosure or use; (e) used or disclosed with the prior written approval of the

to the expiration of such term, may be terminated at any time by either Party giving thirty (30) days prior written notice to the other Party; provided, however, the obligations to protect Proprietary Information contained herein shall survive such expiration or termination for the time period set forth in section 4 herein.

14. No rights or obligations other than those expressly recited herein are to be implied from this Agreement. Neither the execution of this Agreement, nor the furnishing of any information hereunder shall be construed as granting, either expressly or by implication, or otherwise, any license under any invention or patent or other intellectual property now or hereafter owned by or controlled by the Disclosing Party. No license, express or implied, shall inure to the benefit of the other participating Party as a result of a patent being granted to one of the Parties for inventions made exclusively by its employees. None of the information which may be submitted or exchanged by the respective Parties shall constitute any representation, warranty, assurance, guaranty, or inducement by either Party to the other with respect to the infringement of patents, copyrights, trademarks, trade secrets, or any other rights of others.

15. The validity and interpretation of this Agreement shall be governed by the laws of the State of New Jersey.

16. This Agreement is effective as of the date of last signature hereto and is the entire understanding and agreement of the Parties relating to protection of Proprietary Information. Neither Party shall be bound by any additional or other representation, condition, or promise except as subsequently set forth in writing signed by the Party to be bound. This Agreement shall apply in lieu of and notwithstanding any specific legend or statement associated with any Proprietary Information exchanged and the rights and obligations of the Parties shall be determined exclusively by this Agreement. If any portion of this Agreement is held to be invalid, such decision shall not affect the validity of the remaining portions. Each person executing this Agreement represents and warrants that each has full authority to bind his/her company hereunder. Each Party also hereby agrees that a facsimile copy or copies of one or both signatures hereto shall have the full force and effect as an original.

LOCKHEED MARTIN CORPORATION Information Systems & Global Services - Civil	Boise State University
By:__________	By: [signature]
Name: Drew Dotta	Name: Mary Givens
Title: Manager of Subcontracts – IS&GS - GSCM	Title: Director Office of Technology Transfer
Date:__________	Date: 4/6/2010