

Quarterly Report

Project Title:

Development of a Self-Sustained Wireless Integrated Structural
Health Monitoring System for Highway Bridges

Cooperative Agreement # RITARS11HUMD

Second Quarterly Progress Report

Period:

October 15, 2011 through January 14, 2012

Submitted by:

The Research Team – University of Maryland with North
Carolina State University and URS

Submitted to:

Mr. Caesar Singh, Program Manager, US DOT

Date: January 31, 2012

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EXECUTIVE SUMMARY

I — TECHNICAL STATUS

Accomplishments by Milestone

1.1. General

- Prepared for presentation at 2012 TRB meeting (Task 6 and Deliverable 12)
- Updated Project web site (<http://www.ncrst.umd.edu/>) (Task 1 and Deliverable 2)
- Delivered First quarterly financial and technical reports (Task 6 and Deliverable 11)
- Problems resolved: Subcontract agreement with URS was established (Appendix C)
- Conducted meetings with MDSHA on selecting the second bridge for pilot test site. (Baseline, the first, bridge in Maryland selected is US 1 bridge over

Paint Branch.) Br0305602, IS83 SBR over Thornton Mill Rd is our first candidate bridge and Br2204201, IS95 IL over Rhode Island Ave., which is nearby to UMD, is the alternate.

- Scheduled meeting with NCDOT on selecting a bridge in North Carolina for smart sensor testing on Feb. 3, 2012.
- The proposed work plan is shown below as Milestones/Deliverables. Dark Shading indicates Deliverable items and Tasks in which the Research Team has been engaged over the past quarters. Lighter shading indicates anticipated duration for Deliverables by quarter.

Deliverables	Action	Quarter No.									
		1	2	3	4	5	6	7	8	9	10
1	Form TAC and conduct kick-off meeting. Determine baseline field test procedure (Task 1)	Dark									
2	Establish and update project web site (Tasks 1 & 6)	Dark	Dark	Light	Light	Light	Light	Light	Light		
3	Conduct baseline field test and finite element analysis on pre-selected bridges (Task 1)	Dark	Dark								
4	Design, fabricate and characterize AE sensor and measure the performance (Task 2)	Dark	Dark	Light	Light						
5	Develop and evaluate T-R method for passive damage interrogation (Task 3)	Dark	Dark	Light	Light						
6	Develop and experimentally evaluate wireless smart sensor and hybrid-mode energy harvester (Task 4)	Dark	Dark	Light	Light						
7	Implement passive damage interrogation T-R algorithm in the wireless smart sensor on bridges (Task 4)	Light	Light	Light	Light	Light	Light				
8	Integrate and validate AE sensors with wireless smart sensor and hybrid-mode energy harvester (Task 5)	Light	Light	Light	Light	Light	Light				
9	Develop and conduct field implementation/validation of commercial-ready ISHM system with remote sensing capability (Task 5)	Light	Light	Light	Light	Light	Light	Light			
10	Recommend strategy to incorporate remote sensing and prognosis into BMS (Task 5)	Light	Light	Light	Light	Light	Light	Light	Light		
11	Prepare and submit quarterly status and progress reports and final project report (Task 6)	Dark	Dark	Light							
12	Submit paper to conference presentations and publication to TRB meeting or other conferences (Task 6)	Dark	Dark	Light							

- 1.2. PXI System by National Instrument (<http://www.ni.com/pxi/>)
- Set up modules and configured hardware for strain gage acquisition
 - Terminal Block includes bridge completion modules with the capability of attaching 8 strain gages
 - Formatted Labview programming to read strain gage data
 - Enabled the capability of adapting to quarter, half and full bridges
 - Implemented real-time waveforms to observe acquisition visually
 - Configured “detrend” function in Matlab to be used with various amounts and types of data
 - The process of “detrending” data is currently being integrated into Labview
 - Constructed a replica graphical display to PAC software
 - Displays real-time data acquisition from AE sensors in smaller boundaries for better visual analysis
 - Upgraded the memory of the PXI controller (PXIe1082) for faster performance
 - Assembled signal triggering and filtering instruments within the developing Labview programs

1.3 Baseline Bridge Testing

- Performed baseline bridge testing - US 1 bridge over Paint Branch located adjacent to the University of Maryland was field tested on Nov. 21 and Dec. 5, 2011, using strain gages for baseline information. Maximum stress range measured is 1.6 ksi above the diaphragm on girder web in the longitudinal direction due to regular traffic. Stress range records were collected, which will be used as a reference for future testing.
- Conducted validation of the baseline field test – A FEM model of the baseline bridge was established. Appendix A shows the global and local models of the baseline bridge. Natural frequencies of the global model are also shown in the Appendix and they compared well with the tested results.
- Generated an algorithm and Matlab program for stress range analysis

1.4 AE Sensor

- Conducted baseline bridge tests in Maryland and NC: Wireless sensors were used on the baseline bridge (US Route 1 Bridge near UMD campus) to measure its vibration frequency and environmental temperature. The measured information was used in the design of the portable setup for fatigue crack simulation
- Designed and tested AE sensor in the lab (Task 2 and Deliverable 4)- Major work conducted in the second quarter includes:
 - Finalized design of a third-generation flexible piezoelectric paint based acoustic emission (AE) sensor and fabrication of prototype through an external flexible circuit manufacturer;

- Placed purchase order with a local steel shop for the lab fatigue test-setup (including six test specimens and load frames) for conducting lab characterization test of low-profile piezoelectric paint based AE sensor and delivery/assembly scheduled for late January 2012;
- Fine-tuned AE signal noise removal method based on compressed sensing algorithm;
- Designed and fabricated a portable setup to simulate fatigue crack propagation. The setup consists of a steel base plate, two steel bars welded to the base plate and proper weight to simulate the bridge vibration frequency (around 3.4 Hz). The setup is currently being tested under fatigue load to generate fatigue crack at the welded joint of steel bar and base plate. Piezoelectric paint sensors have been installed on the base plate to monitor any AE signals caused by fatigue crack initiation and propagation;
- Further developed a Labview-based virtual instrument software for data acquisition of AE data. To enable automated AE feature extraction and advanced signal processing, a database software (Microsoft Access) and Matlab were used. A near-field AE monitoring strategy is being refined for low-profile piezoelectric paint based AE sensor, which employs a stress-wave-based AE sensing principle and thus has the advantage of improved representation of crack source information. This near-field AE monitoring strategy has been validated using a calibration steel block as well as analytical/numerical results.

1.5 T-R Method, Energy Harvesting and Smart Sensor

Accomplishments of these tasks are detailed in Appendix B and summarized here:

- Enhanced a new wireless sensor based on the prototype wireless intelligent sensor platform developed at the NC State. (Task 3 and Deliverable 5 & Task 4 and Deliverable 6)
- Enhanced and evaluated physics-based model (Task 4 and Deliverable 6)
- Enhanced and evaluated wind turbine energy harvester (Task 4 and Deliverable 6)

1.6 Future Plans

Baseline and Pilot Bridge Testing -

- Continue evaluating and validating results from the baseline test bridge (US Route 1 Bridge near UMD campus)
- Field testing AE sensors on the pilot test bridge in Maryland
- Field testing T-R method, energy harvesting and smart sensors on the pilot test bridge in NC
- Generating FEM models for all pilot test bridges in Maryland and NC

- Validating test data with FEM results

AE Sensor -

- Conducting baseline bridge tests in Maryland and NC: In the next quarter, fatigue crack will be generated in the portable setup, and piezoelectric paint AE sensors will be installed on this portable setup, which will be clamped to the flange of the pilot study bridge (Route 1 bridge near UMD campus) to characterize and debug the AE sensors in the wireless SHM system.
- Continue enhancing and testing AE sensor in the lab - the design of third-generation piezoelectric paint-based AE sensor has been finalized and product (400 AE sensors) was delivered by an external flexible circuit manufacturer. The next quarter will involve testing and characterizing these AE sensor prototypes on fatigue test specimens along with development and verification of its wireless sensing feature. It is scheduled for field tests of piezoelectric paint based AE sensors installed on the portable fatigue test setup on the US Route-1 bridge. Continue developing and evaluating T-R method - Different spacing for calibration is being conducted experimentally to determine the probability of AE detection. Duration of the sensor data for providing higher resolution will be optimized.

T-R Method, Energy Harvesting and Smart Sensor -

- Building the new wireless intelligent sensor platform with an active piezoelectric emit channel which can drive the piezoelectric sensor for excitation.
- Continue designing and testing wind turbine energy harvester-Currently the manufacture and laboratory test on the miniature wind turbine is being finalized. The future works will involve fabrication of a wind facing auto-rotate system which will be installed on the wind turbine.
- Continue designing and testing interface circuit design-Based on the miniature wind turbine tests results, an interface circuit for storing the output power generated by miniature wind turbine will be designed and tested. A proper battery capacity for this interface circuit will be selected for long-term power supply.

II — BUSINESS STATUS

- Hours/Effort Expended – PI Dr. Fu worked one month paid by his cost sharing account for 167 man-hours. Three (3) UM and two (2) NCSU graduate assistants worked three months half-time (20 hours), the quarterly accounting deadline, for a total of 1,470 man-hours (one NCSU assistant is partially cost-shared by their University.)

- Hours/Effort spent by the MD & NC States for in-kind cost share are not counted for here.
- Funds Expended and Cost Share –
 - Listed and invoiced in this Quarterly Federal Financial Report (period ending on December 31, 2011): Federal share of expenditure requested for this quarter \$91,521.54 [Federal share total \$134,072.29; Recipient share of expenditure (cost share) \$18,388.88; Cumulative Total \$152,461.27]
 - Spending not included in this last Quarterly Federal Financial Report but included in this report: NCSU invoice to 9/30/2011 \$39,411.27 & cost share \$2,844.67, URS \$940.40; Dr. Fu’s cost sharing account \$14,711.1;
 - Equipment purchase receipts of NI equipment software purchase \$897.39; NI DAQ system purchase \$16,666.70 were included in the last quarterly report but spending is included in this report
 - The following matching funds were from the \$50K match of Dr. Y. Zhang’s startup account (see Appendix D)
 1. Chesapeake Lighting Associates, Inc., six fatigue test specimens to validate and characterize piezoelectric paint based AE sensors, \$4530.00
 2. Thrifty Iron Works, Inc., fatigue load frames, \$8,100.00
 3. National Instruments, Labview database toolkit, \$267.38
 4. National Instruments, 800KS/s data acquisition unit, \$2,697.08

Appendix A – FEM Analysis of the Baseline Bridge

Appendix B – Executive Summary of the Smart Sensor and Energy Harvesting Development

Appendix C - Copies of Subcontract (URS)

Appendix D – Copies of Equipment Purchase Receipts

Appendix A – FEM Analysis of the Baseline Bridge
Skewed Paint Branch Bridge on US Route 1

A.1. Frequencies and Modal Shapes of the Baseline Bridge

The first mode shape is vertical bending with the frequency of 3.34 HZ. Table A.1 and pictures below show the results.

TABLE A.1: Modal Periods And Frequencies						
OutputCase	StepType	StepNum	Period	Frequency	CircFreq	Eigenvalue
Text	Text	Unitless	Sec	Cyc/sec	rad/sec	rad2/sec2
MODAL	Mode	1	0.299005	3.3444	21.014	441.57
MODAL	Mode	2	0.197953	5.0517	31.741	1007.5
MODAL	Mode	3	0.147149	6.7958	42.699	1823.2
MODAL	Mode	4	0.14476	6.908	43.404	1883.9
MODAL	Mode	5	0.131094	7.6281	47.929	2297.2
MODAL	Mode	6	0.099403	10.06	63.209	3995.4
MODAL	Mode	7	0.098882	10.113	63.542	4037.6
MODAL	Mode	8	0.080839	12.37	77.725	6041.2
MODAL	Mode	9	0.068958	14.502	91.116	8302.1
MODAL	Mode	10	0.065437	15.282	96.019	9219.7
MODAL	Mode	11	0.064664	15.465	97.166	9441.3
MODAL	Mode	12	0.063738	15.689	98.578	9717.7

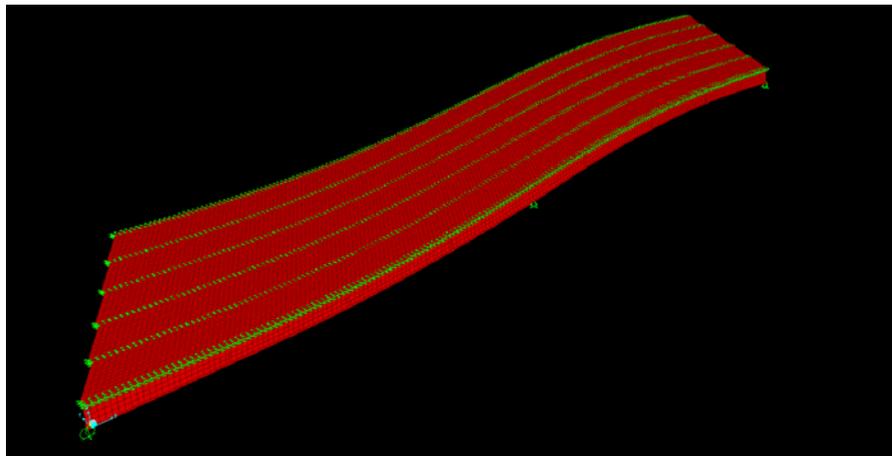


Figure A.1 - The 1st mode shape—vertical bending

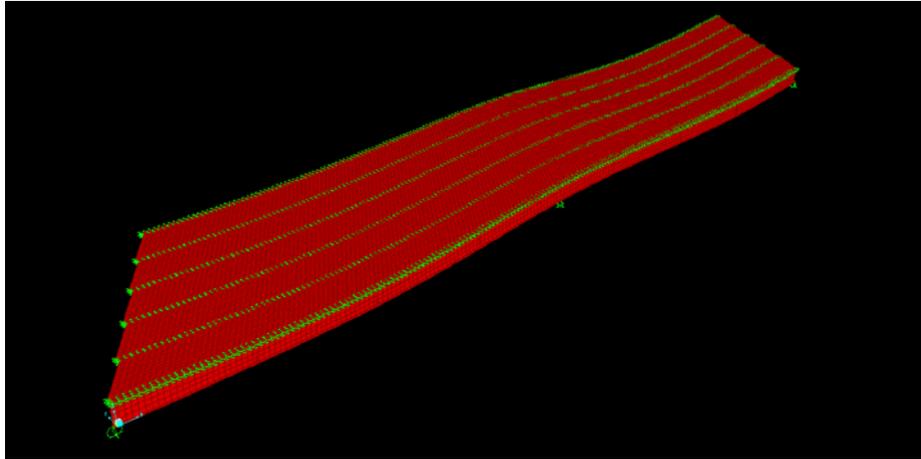


Figure A.2 - The 2nd mode shape-- vertical bending

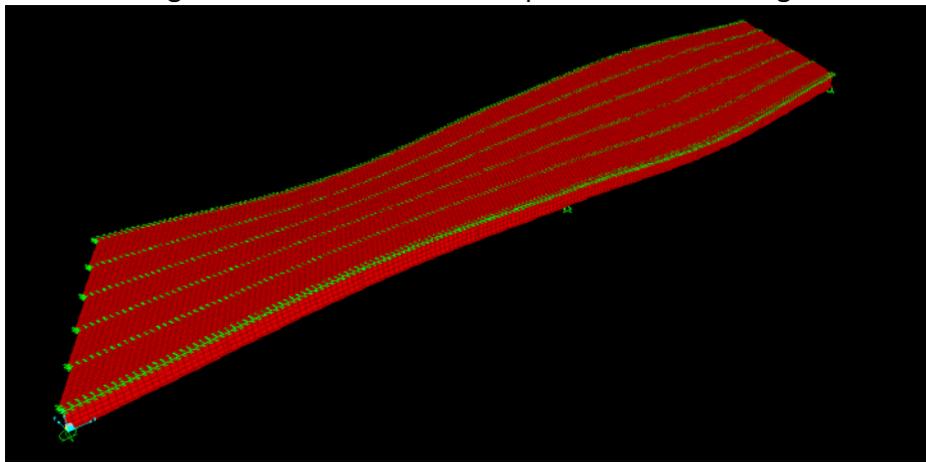


Figure A.3 - The 3rd mode shape—torsion

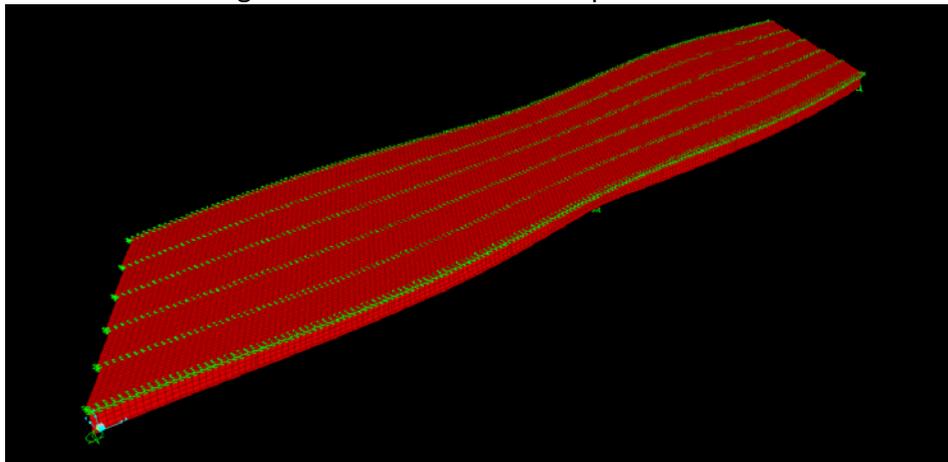


Figure A.4 - The 4th mode shape—torsion

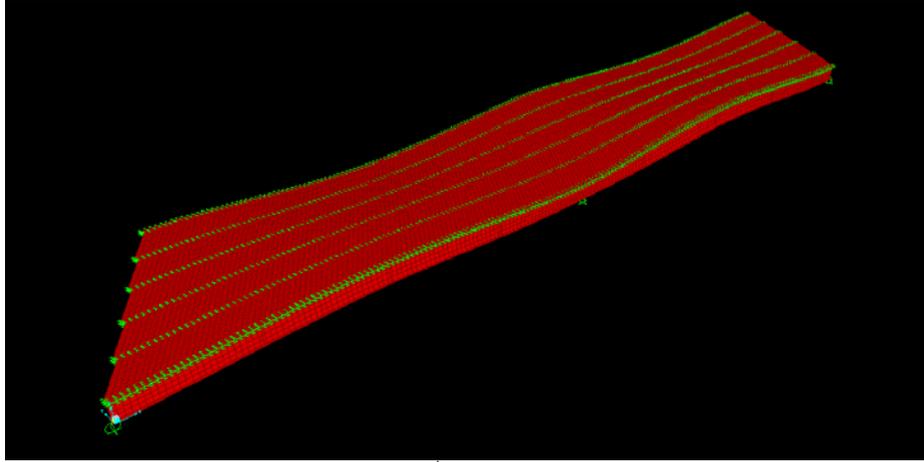


Figure A.5 - The 5th mode shape—torsion

A.2. The Influence Surface

Influence surfaces generated by the SAP2000 program are used to place loading in order to obtain the stress ranges with simulated traffic loading

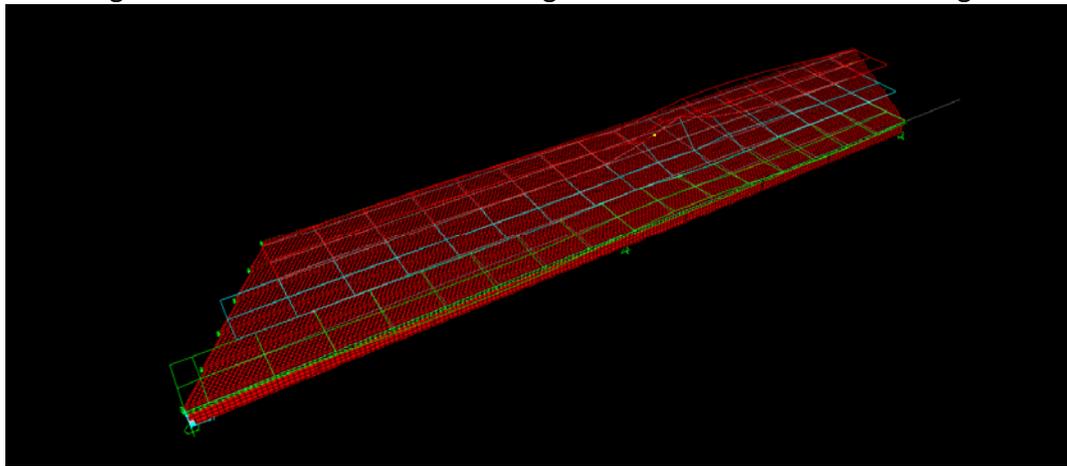


Figure A.6 - The influence surface of shell stress at V1 sensor location

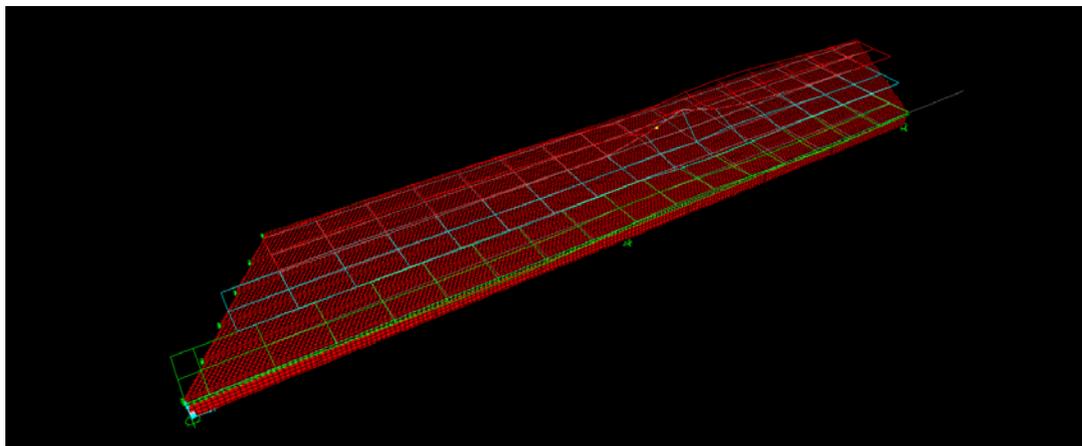


Figure A.7 - The influence surface of shell stress at V2 sensor location

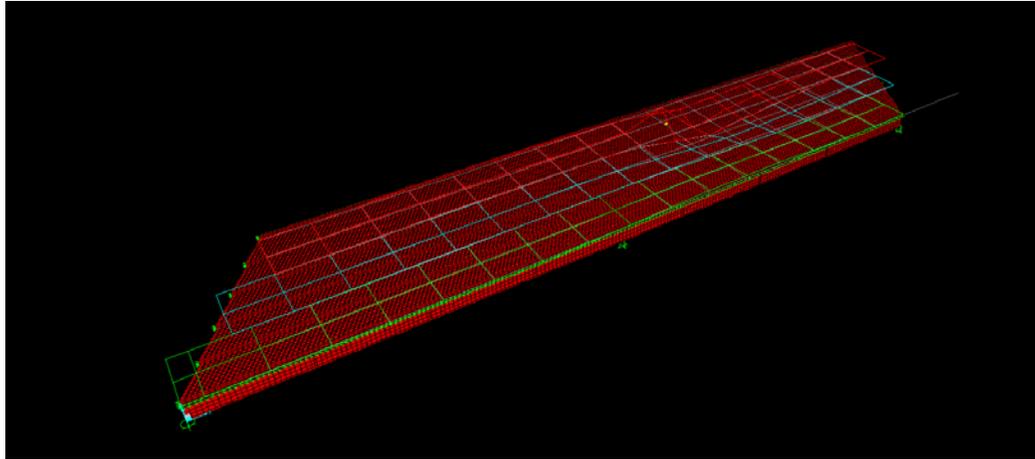


Figure A.8 influence surface of shell stress at V3 sensor location

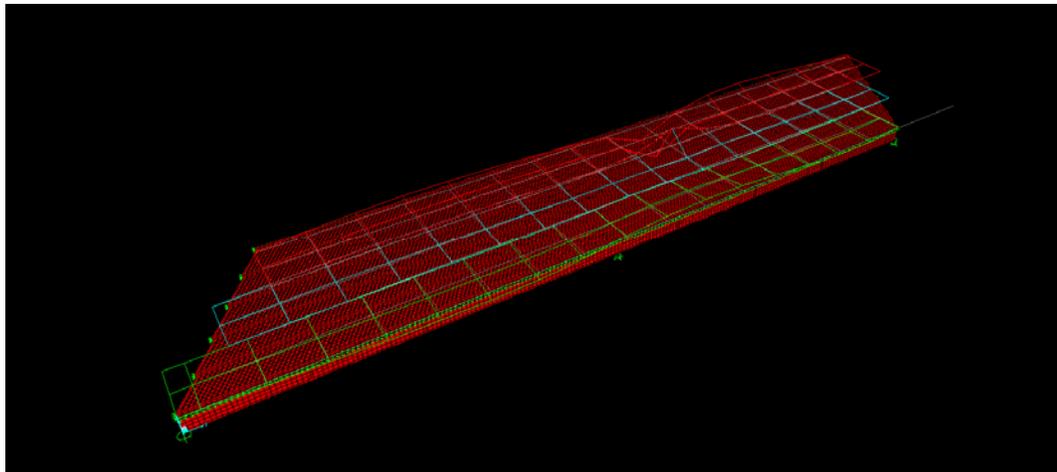


Figure A.9 - The influence surface of shell stress at V4 sensor location

A.3. The Local Model

The local model is used to find the stress concentration at possible crack locations. The deck boundary was fixed from translation along the edges parallel to the girders. With both global- and local-models for this bridge available, the girder differential deflection and deck edge node rotations can be found from the global-model and then applied to the local model to determine the web-gap movement and stress field.

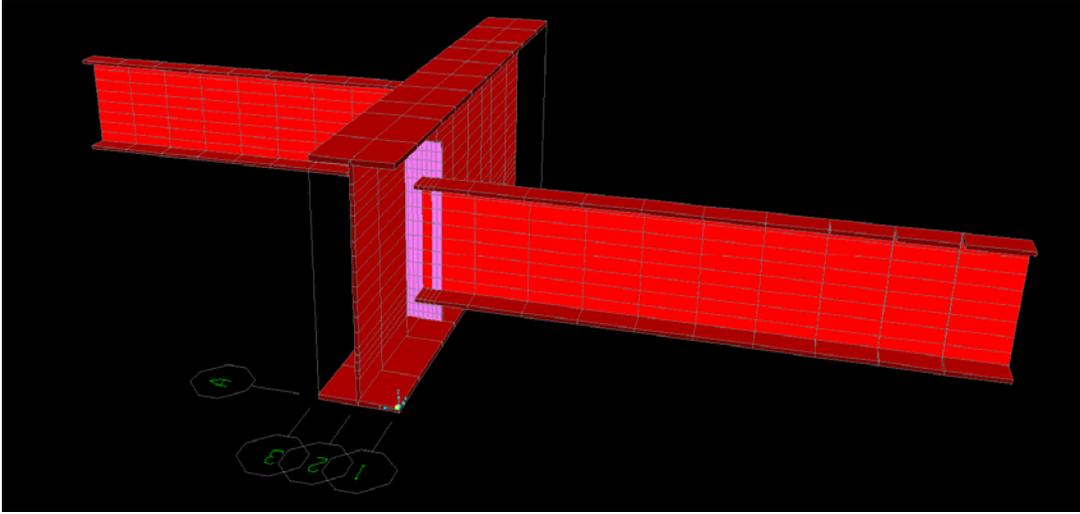


Figure A.5 – Local Model at the Measurement Locations

Appendix B – Technical Summary of the Smart Sensor and Energy Harvesting Development

TECHNICAL STATUS

Accomplishments by milestone

- Enhancing a new wireless sensor – Based on the prototype wireless intelligent sensor platform developed at the NC State. Instead of one separate channel on one PCB board, four (4) piezoelectric sensors are included in the system together on one PCB board. The new design can detect the signals of Four (4) piezoelectric sensors synchronously.

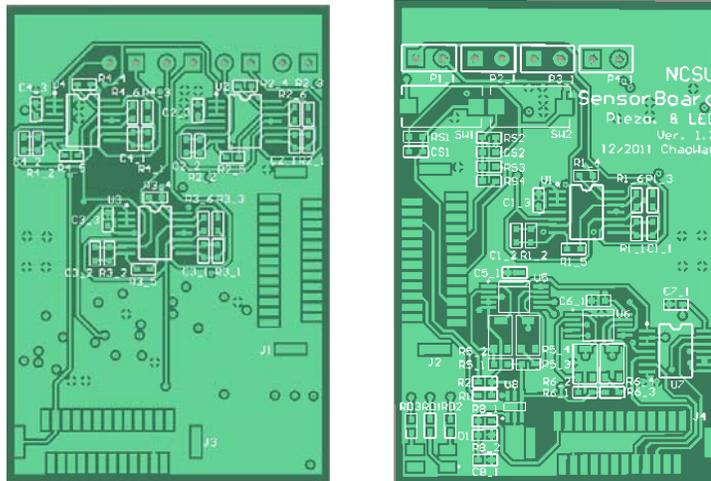


Figure B.1 The new PCB design of the piezoelectric sensor board

The new piezoelectric sensor interface board has two main parts. The first part is called charge amplifier circuit which is used to transduce the electronic signal to voltage signal. In this part, there are four (4) same circuits for four (4) individual channels. The second part is a quadruple analog switch which is used to switch the four (4) different channels' signal to a DAC (Digit to Analog Converter). By using the quadruple analog switch, the four (4) piezoelectric signals can share one DAC. It will compact the PCB board much smaller.

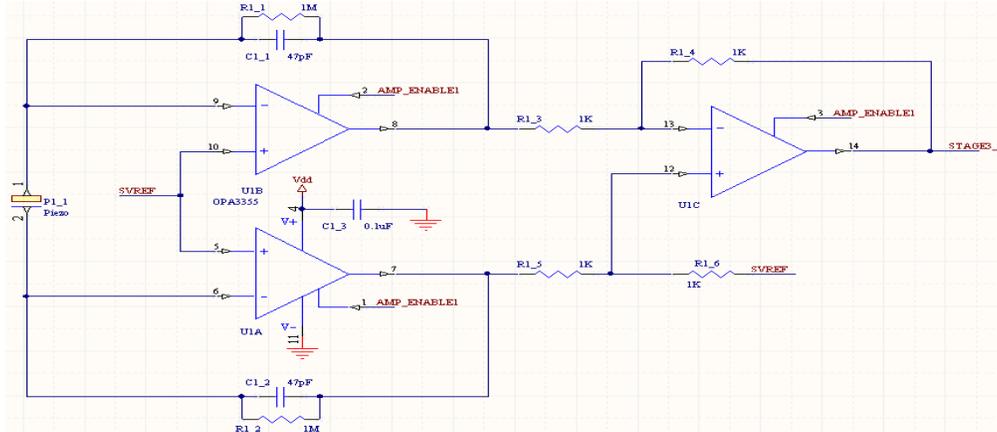


Figure B.2 One channel charge amplifier circuit for piezoelectric sensor

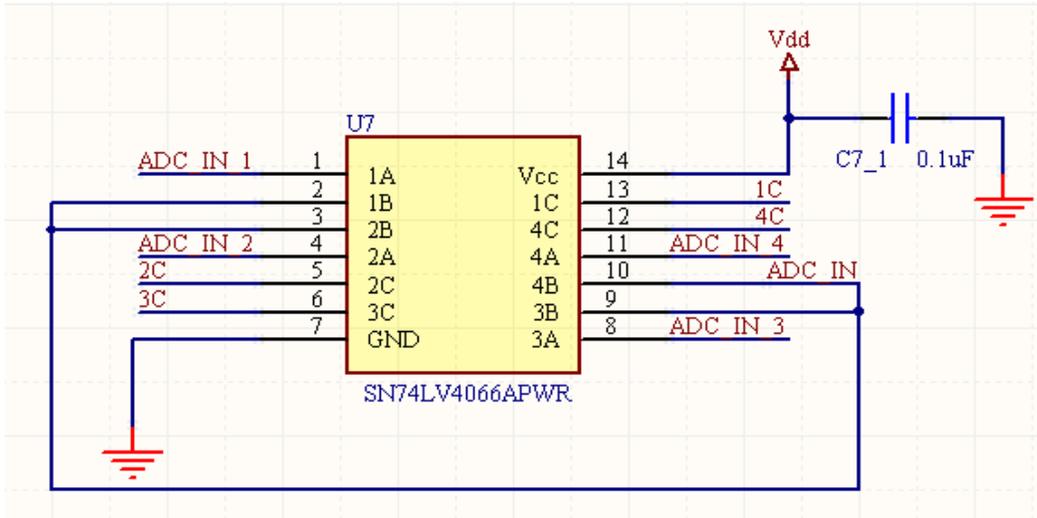


Figure B.3 Quadruple analog switch for 4 channel piezoelectric signal

- Enhancing and evaluating physics-based model- A comprehensive physics-based model for predicting the performance of a miniature wind turbine was developed. Laboratory tests for verifying the physics-model have been performed. The experimental results demonstrated that the physics-based model holds promise in estimating and optimizing the performance of the miniature wind turbine.
- Enhancing and evaluating wind turbine energy harvester-A miniature wind turbine (MWT) for energy harvest have been manufactured and tested under the resistive loads from 10 Ω to 461 Ω at the wind speeds of 2, 2.5, 3, 3.5, 4 and 4.5 m/s, as shown in Figure B.4.

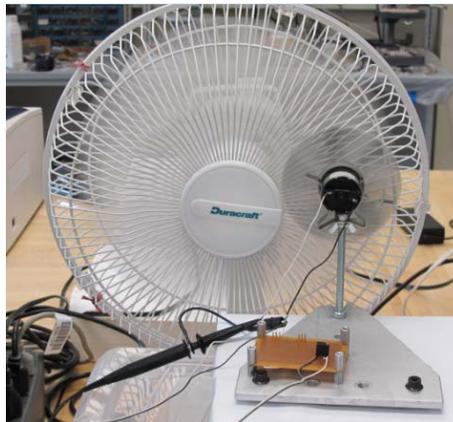


Figure B.4 Test photo of the MWT

The output voltages obtained from experiments are shown in Figure B.5. It can be seen that the output voltage of the MWT increases with the increase of the resistive load and then reaches a plateau. According to the tested results, the open circuit voltage of MWT can reach about 1.2 V at the speed of 2.0 m/s and reach 2.9 V at the speed of 4.5 m/s.

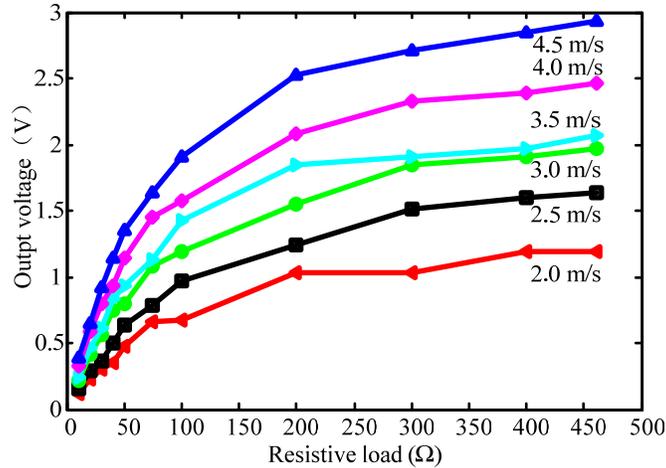


Figure B.5 Tested output voltage of the MWT

Figure B.6 shows the tested output power curves for various loads. It can be seen clearly from the tested power curve that the optimal load resistance is about 50-100 Ω when the wind speed ranging from 2 m/s to 4.5 m/s. The maximum output power under the optimal load resistance can be reached about 5 mW at the wind speed of 2 m/s and more than 35 mW at the wind speed of 4.5 m/s, which could be used for powering low-power wireless sensors.

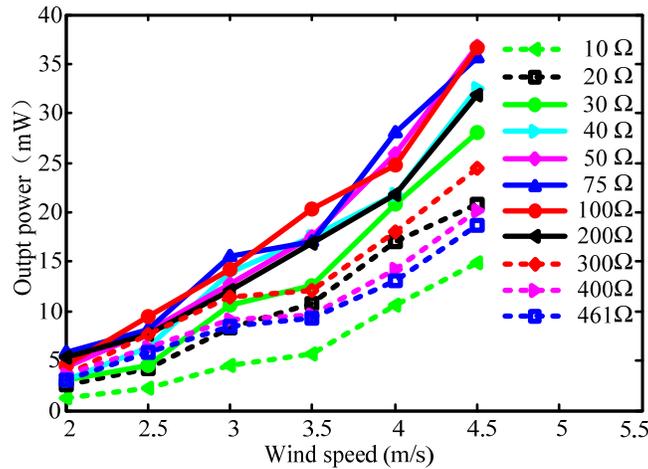


Figure B.6 Tested output power of the MWT

The tested system efficiencies of the MWT are shown in Figure B.7. It can be seen that the MWT reaches its maximum system efficiencies at the optimal resistive load (50, 75 or 100 Ω). The maximum system efficiency can reach up to 15.4% at the optimal resistive load with the wind speed of 2 m/s.

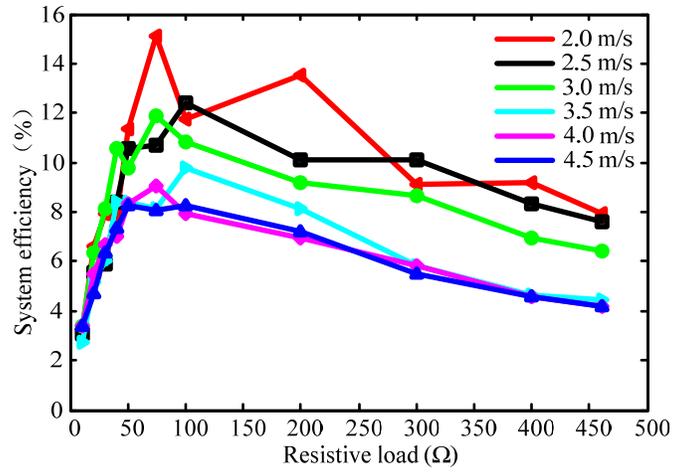


Figure B.7 Tested system efficiency of the MWT

**UNIVERSITY OF MARYLAND
COLLEGE PARK, MARYLAND 20742**

SUBCONTRACT No. Z981002

This Subcontract, by and between the University of Maryland, College Park, ("UM") a public corporation and instrumentality of the State of Maryland, located at College Park, Maryland 20742, (hereinafter referred to as the "UM") and URS Group, Inc., a Delaware corporation (hereinafter referred to as "SUBCONTRACTOR").

WITNESSETH

WHEREAS, UM in furtherance of its education and research mission is the recipient of funds from the U.S. Department of Transportation (hereinafter referred to as Prime Sponsor); and UM is desirous of engaging SUBCONTRACTOR to provide work associated with the Project titled "Development of a Self-Sustained Wireless Integrated Structural Health Monitoring System for Highway Bridges" under Prime Award No. RITARS11HUMD; CFDA No. 20.701.; and

WHEREAS, SUBCONTRACTOR is prepared and willing to provide the aforementioned work,

NOW THEREFORE, in consideration of the above premises and of the mutual promises and other good and valuable considerations set forth below, UM and SUBCONTRACTOR agree as follows:

1. STATEMENT OF WORK

SUBCONTRACTOR agrees to furnish work to be done under this SUBCONTRACT in accordance with its proposal and budget incorporated herein as Attachment A.

2. PERIOD OF PERFORMANCE

The period of performance of this SUBCONTRACT shall be July 15, 2011 through July 14, 2013.

3. KEY PERSONNEL

The following SUBCONTRACTOR individual(s) are considered key personnel essential to the work under the SUBCONTRACT. SUBCONTRACTOR will notify UM in writing of any changes in key personnel. Any change in the individual(s) or their level of effort requires written modification to this SUBCONTRACT.

Dr. Y. Edward Zhou

Appendix C

SUBCONTRACT NO. Z981002

4. POINTS OF CONTACT & SUBCONTRACT INFORMATION

The following serve as the representatives of UM and SUBCONTRACTOR in the areas indicated:

(a) For UM:

(i) **TECHNICAL REPRESENTATIVE**

Name/Title Dr. Chung C. Fu
Address 1 Civil & Environmental Engineering
Address 2 1129 Engineering Laboratory Building
Address 3 University of Maryland
Address 4 College Park, MD 20742-3021
Phone (301) 405-2011
Email ccfu@umd.edu

(ii) **ADMINISTRATIVE REPRESENTATIVE**

Name/Title Jill A. Frankenfield
Address 1 Office of Research Administration and Advancement
Address 2 3112 Lee Building
Address 3 University of Maryland, College Park
Address 4 College Park, Maryland 20742-5141 USA
Phone (301) 405-4577
Email jfranken@umd.edu

(b) For SUBCONTRACTOR:

(i) **ORGANIZATION INFORMATION**

Address 1 URS Group, Inc.
Address 2 4 North Park Drive
Address 3 Suite 300
Address 4 Hunt Valley, Maryland
Zip Code +4 21030-1830

Congressional District District 6
EIN 94-3077384
DUNS 126-483-903
Parent Organization Name URS Corporation
Parent DUNS 04-327-1568

Appendix C

SUBCONTRACT NO. Z981002

Is the SUBCONTRACTOR currently registered in CCR? Yes No

Does Subrecipient's gross income, from all sources, in the previous tax year exceed \$300,000? Yes No

Is SUBCONTRACTOR exempt from reporting compensation? Yes No
If no, complete the Reporting of Total Compensation of Subrecipient Executives Appendix.

(ii) **TECHNICAL REPRESENTATIVE**

Name/Title Dr. Y. Edward Zhou
Address 1 12420 Milestone Center Drive
Address 2 Suite 150
Address 3 Germantown, Maryland 20876-7112
Address 4
Phone 301-820-3539
Email ed.zhou@urs.com

(iii) **ADMINISTRATIVE REPRESENTATIVE**

Name/Title Nicholas G. Deros
Address 1 4 North Park Drive
Address 2 Suite 300
Address 3 Hunt Valley, Maryland 21030-1830
Address 4
Phone 410-891-9212
Email nick.deros@urs.com

(iv) **PLACE OF PERFORMANCE (ZIP+4 required)**

Address 1 12420 Milestone Center Drive
Address 2 Suite 150
Address 3 Germantown, Maryland
Address 4
Zip Code +4 20876-7112
Congressional District of Performance Location District 4

5. INVOICING AND PAYMENT

- (a) UM hereby awards a cost reimbursable SUBCONTRACT, in an amount not to exceed \$110,000 to SUBCONTRACTOR.

Funds provided by this action represent the total amount obligated under this SUBCONTRACT.

- (b) UM shall pay SUBCONTRACTOR on a cost reimbursement basis not more often than monthly for allowable costs.

Appendix C

SUBCONTRACT NO. Z981002

- (c) SUBCONTRACTOR shall submit invoices in general accordance with its approved budget to UM at the following address:

Accounts Payable
3101 Chesapeake Building
University of Maryland
College Park, MD 20742
Phone: 301-405-2644

SUBCONTRACTOR may submit an electronic invoice in lieu of a hard copy to:
apadmin@umd.edu

- (d) All cost reimbursement invoices shall be submitted using SUBCONTRACTOR'S standard federal invoice format showing expenses broken out by general cost categories and current and cumulative costs to date. All invoices must include SUBCONTRACT Number, SUBCONTRACTOR'S Federal ID Number and certification as to truth and accuracy of invoice. *Invoices that do not reference UM's SUBCONTRACT Number shall be returned to SUBCONTRACTOR.* Expenditures of SUBCONTRACTOR shall conform to budget in Attachment A. Non-compliance with these instructions may result in the withholding of payment. UM shall pay undisputed portions of each progress invoice within thirty (30) days of the date of the invoice.
- (e) A final invoice, marked "FINAL," must be submitted NOT LATER THAN sixty (60) days after SUBCONTRACT end date to be honored by UM. All payments shall be provisional subject to adjustment within the total obligation or authorized amount in the event such adjustment by the prime sponsor is necessary as a result of an audit finding against *the SUBCONTRACTOR.*
- (f) *Cost sharing is not required under this SUBCONTRACT.*

6. **PERFORMANCE**

SUBCONTRACTOR is obligated to comply with applicable standards of normal engineering care in the performance of the services and covenants that the services will be performed in accordance with the specifications set forth in the statement of work. UM recognizes that opinions relating to environmental, geologic, and geotechnical conditions or other estimates are based on limited data and that actual conditions may vary from those encountered at the times and locations where the data are obtained, despite the use of due care. SUBCONTRACTOR hereby disclaims all other warranties both express and implied. [The SUBCONTRACTOR will provide best efforts in performing the work under this SUBCONTRACT and services will be rendered at a level commensurate with professional standards acceptable in the discipline and within the scope of the project.

7. **REPORTS**

SUBCONTRACT NO. Z981002

The SUBCONTRACTOR shall submit the following reports:

TYPE		FREQUENCY AND/OR DUE DATES
Technical	Progress/Status	Quarterly
	Final	Within 60 days award end date
Financial	Progress/Status	Quarterly
	Final	Within 60 days of award end date
Patent	Final	Within 60 days of award end date

Please forward Technical reports to UM's Technical Representative. All Final Patent and Close Out reports should be sent electronically or in hard copy to:

University of Maryland, Office of Research Administration & Advancement
 ATTN: Compliance Office
 3112 Lee Building, College Park, MD 20742
 Email: oraacompliance@umd.edu
 Phone: 301-405-6280

8. ASSIGNMENT OF RIGHTS

SUBCONTRACTOR shall not assign or transfer its rights or obligations hereunder without the prior written approval by the Administrative Representative of UM. Purchase of a controlling interest in SUBCONTRACTOR by a third party shall be deemed an assignment.

9. EQUIPMENT

No funds authorized for the purchase of equipment.

10. INTELLECTUAL PROPERTY

- (a) Research Results means all data, inventions, discoveries, copyrightable works, software, tangible materials and information that are conceived of, first reduced to practice, collected or created in the performance of the Statement of Work and funded under this Subaward. Patenting and copyright of Research Results shall be handled in accordance with the agency specific terms and conditions incorporated as Attachment B.
- (b) SUBAWARDEE agrees to grant and hereby grants an irrevocable, nonexclusive, nontransferable, non-assignable, royalty-free right and license in Research Results of which it is the exclusive owner pursuant to Section 10(b) to UM for its use solely

Appendix C

SUBCONTRACT NO. Z981002

in support of non-commercial research or educational purposes and to the extent required to meet UM's obligations to the Prime Sponsor.

11. CONFIDENTIAL INFORMATION

- (a) Each party will maintain in confidence any confidential information owned by one and accepted by the other during the course of the SUBCONTRACT.
- (b) Acceptance by one party of the other's confidential information (as evidenced by receipt thereof without objection within 30 days), means that party agrees to exercise reasonable efforts:
 - i. not to publish or otherwise reveal said confidential information to third parties without the permission of the other;
 - ii. not to discuss the confidential information to persons not having a "need to know";
 - iii. to use the confidential information only in fulfillment of obligations hereunder.
- (c) Confidential information must be marked or designated in writing on its face page as proprietary or confidential. If disclosed orally, confidential information shall be reduced to writing by the disclosing party and forwarded to the receiving party's Technical Representative named in Article 4 within fifteen (15) business days.
- (d) Each party retains the right to refuse to accept any such confidential information which it does not consider to be essential to performance of research pursuant to this SUBCONTRACT, or which it believes to be improperly designated. The parties agree that no classified information will be exchanged under this agreement.
- (e) "Confidential Information" is hereby defined as drawings, disclosures, designs, data, reports, calculations, models, component parts, patent applications, software, software models, trade secrets, proprietary data, product designs and developments, research reports, market studies and plans, confidential business information or the like, but shall not include information which: (1) the receiving party develops independently and without the benefit of Confidential Information of the disclosing party; (2) is in the knowledge or possession of one party at the time of disclosure by one to the other and proof thereof is made promptly; (3) is now or hereafter becomes public knowledge; (4) is subsequently received without binder of secrecy by one party from a third party, not owing obligations of secrecy to the other party; (5) the receiving party is obligated to produce to comply with applicable laws or regulations, including the Maryland Public Information Act, or pursuant to an order of a court of competent jurisdiction or a valid administrative or congressional subpoena provided the receiving party notifies the disclosing party prior to making such a disclosure so that the disclosing party may take appropriate action.
- (f) Except as otherwise provided herein, neither party will sell, use, disclose, publish

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or make copies of the confidential information or disclose the confidential information to any third party without the prior written approval of the owning party.

12. EXPORT CONTROL

- (a) The SUBCONTRACTOR shall comply with all applicable U.S. export control laws and regulations, specifically including, but not limited to, the requirements of the Arms Export Control Act, including the International Traffic in Arms Regulation (ITAR), and the Export Administration Act, including the Export Administration Regulations (EAR), as well as the applicable regulations of the Office of Foreign Assets Control (OFAC) (collectively, "Export Control Regulations").
- (b) The parties do not anticipate the need to disclose to each other technical data or information, whether in a tangible or intangible form, that are subject to Export Control Regulations. Should one party believe it is necessary to disclose technical data or information that are controlled under Export Control Regulations, the Disclosing Party shall notify the Recipient's Export Compliance Officer and provide specific identifying references as to the part of the EAR, ITAR, or other regulations under which the materials are qualified as "export controlled." No transfer of controlled materials will occur without the prior written consent of the Recipient's Export Compliance Officer. Neither party is obligated to accept Export Controlled technical data or information. The Receiving Party will incur no liability if it elects not to accept export controlled technical data or information.

13. PUBLICATION

- (c) Nothing in this agreement is intended to interfere with either party's right to publish, present or otherwise disseminate papers and information relating to the results arising from this SUBCONTRACT.
- (d) Prior to submission for publication or public presentation of a manuscript or abstract describing Research Results, the publishing party will send a copy of the proposed manuscript or abstract to the other party. Within thirty (30) days of the other party's receipt of the manuscript or abstract, the other party shall identify, in writing, for the publishing party specific information in the manuscript or abstract that the other party identifies as patentable or the other party's Confidential Information. The publishing party may proceed with release/publication of information if the non-publishing party does not respond within the thirty (30) day review period.
- (e) SUBCONTRACTOR shall comply with all publication requirements listed in the terms and conditions of the Prime Award incorporated as Attachment B.

14. TERMINATION

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- (a) The performance of work under this SUBCONTRACT may be terminated by UM for convenience, in accordance with this clause, in whole or in part, if UM determines that termination is in its best interest. UM will pay all reasonable costs associated with this SUBCONTRACT incurred by SUBCONTRACTOR up to the date of termination.
- (b) In the event of default by SUBCONTRACTOR due to gross negligence, willful misconduct, or material failure to meet its obligations under this SUBCONTRACT, performance by SUBCONTRACTOR may be terminated by UM with an immediate written STOP WORK notice to SUBCONTRACTOR. SUBCONTRACTOR may present UM with a final statement of expenses and non-cancellable commitments up to the date of termination and the parties will negotiate an equitable settlement proportionate to the deliverables received from the SUBCONTRACTOR by UM upon termination. Under this clause, UM will only reimburse for those costs to the SUBCONTRACTOR which are allowed and reimbursed to UM by the Prime Sponsor.
- (c) In the event that the GOVERNMENT for any reason terminates work by UM on this subject matter, then performance by SUBCONTRACTOR may be terminated by UM by written notice to SUBCONTRACTOR under the same terms of termination as are applied to UM. SUBCONTRACTOR shall receive the same notice of termination for cause as the GOVERNMENT provides to UM under the Prime Award.

15. LIABILITY

UM (its officers, agents and employees) shall not be liable for any injury, damage, or loss to persons or property caused by the negligence or willful misconduct of SUBCONTRACTOR (its officers, agents and employees) which may arise in the performance of this SUBCONTRACT. SUBCONTRACTOR shall indemnify and hold UM (its officers, agents and employees) harmless from any and all claims to the proportionate extent caused by the negligence of SUBCONTRACTOR (its officers, agents and employees) in the performance of this SUBCONTRACT.

16. AUDIT

- (a) Within 15 days following written request by UM, SUBCONTRACTOR shall make available for inspection and/or audit any and all records related to its performance under this SUBCONTRACT. Said records are subject to inspection and audit by representatives of UM, the Prime Sponsor, and the Comptroller General of the United States during reasonable business hours throughout the term of this SUBCONTRACT and for the three (3) years immediately following UM's notification of final closeout to SUBCONTRACTOR under this SUBCONTRACT. In the event an audit is initiated by UM during the three (3) years following closeout, SUBCONTRACTOR agrees to retain any and all records associated with this SUBCONTRACT until such time as any disputes and appeals arising from an audit of records are resolved. All audit disallowances under this SUBCONTRACT shall be the responsibility of SUBCONTRACTOR and shall be reimbursed to UM if

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payment has already occurred.

- (b) SUBCONTRACTOR acknowledges that it is aware of and agrees to comply with the requirements of FAR 52.215-2 Audit and Records – Negotiation. Upon request, SUBCONTRACTOR agrees to provide UM with financial information related to the most recent independent audit attesting to the fact that SUBCONTRACTOR'S records are in accordance with federal cost accounting standards.

17. INDEPENDENT CONTRACTOR

UM contracts for the services of SUBCONTRACTOR as an independent contractor and not as an employee.

18. PUBLICITY

No press release, public service announcement, or advertisement shall be made by SUBCONTRACTOR containing a reference to UM without their prior written approval.

19. GENERAL PROVISIONS

This SUBCONTRACT is further governed by the agency specific terms and conditions which are appended hereto and incorporated as Attachment B.

These provisions are hereby flowed down to SUBCONTRACTOR. SUBCONTRACTOR agrees to perform this work in accordance with said provisions. For purposes of this SUBCONTRACT, the following terms contained in Attachment B shall have the following meanings: (1) the term SPONSOR, GRANTOR, GOVERNMENT, USDOT, BUYER, or CLIENT shall mean UM; (2) the term HEAD OF THE AGENCY, AGENCY HEAD, SECRETARY, CONTRACTING OFFICER, or GRANTS OFFICER shall mean the DIRECTOR, OFFICE OF RESEARCH ADMINISTRATION AND ADVANCEMENT at UM; (3) the term GRANTEE, RECIPIENT, AWARDEE, CONTRACTOR, SELLER, or VENDOR shall mean SUBCONTRACTOR.

In the event of inconsistency between the conditions of this SUBCONTRACT and those of the aforementioned ATTACHMENTS, the inconsistency shall be resolved by giving precedence in the following order: (1) this SUBCONTRACT; (2) the Statement of Work and (3) the Agency Specific Terms and Conditions

20. REGULATORY COMPLIANCE

SUBCONTRACTOR shall comply with all applicable laws, regulations and requirements of the Prime Sponsor, including but not limited to those listed below:

Appendix C

SUBCONTRACT NO. Z981002

Acceptance of this SUBCONTRACT constitutes certification that the:

- (a) SUBCONTRACTOR is not presently debarred, suspended, proposed for debarment, declared ineligible or voluntarily excluded from covered transactions by any Federal Department or Agency.
- (b) SUBCONTRACTOR is not delinquent on any Federal debt.
- (c) SUBCONTRACTOR will comply with the requirements of the Drug-Free Workplace Act PL 100-690, Title V, Subtitle D.
- (d) SUBCONTRACTOR will comply with the requirements of the Equal Employment Opportunity Act. E.O.11246, as amended by E.O.11375, and as supplemented by regulations at 41 CFR Part 60.
- (e) SUBCONTRACTOR will comply with the requirements of the Clean Air Act (42 U.S.C. 7401 et seq.) and the Federal Water Pollution Control Act (33 U.S.C. 1251 et Seq.) as amended.
- (f) SUBCONTRACTOR certifies that no federally appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of Congress, or an employee of a Member of Congress in connection with this SUBCONTRACT, and that if any funds other than federally appropriated funds have been or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this SUBCONTRACT, SUBCONTRACTOR shall complete and submit Standard Form LLL, "Disclosure of Lobbying Activities."
- (g) SUBCONTRACTOR has a written policy concerning conflicts of interest that is in compliance with Prime Sponsor's Policy.
- (h) SUBCONTRACTOR certifies that an annual and/or A-133 audit is performed and that the most recent audit report contained no findings of material weakness, material instances of noncompliance, or finding related to any SUBCONTRACT involving the University of Maryland.
- (i) SUBCONTRACTOR agrees to notify UM promptly if there is any change of status in any of the above certifications.
- (j) **TRAFFICKING IN PERSONS**
1) SUBCONTRACTOR, SUBCONTRACTOR employees, subrecipients under this award, and subrecipients' employees may not engage in severe forms of trafficking in persons during the period of time that the award is in effect; procure a commercial sex act during the period of time that the award is in effect; or use forced labor in the performance of the award or SUBCONTRACTS under the award.

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2. UM may unilaterally terminate this award, without penalty, if SUBCONTRACTOR or a subrecipient that is a private entity is determined to have violated a prohibition in paragraph 1 of this award term; or ii. Has an employee who is determined by the agency official authorized to terminate the award to have violated a prohibition in paragraph 1 of this award term through conduct that is either a) Associated with performance under this award; or b) Imputed to SUBCONTRACTOR or the subrecipient using the standards and due process for imputing the conduct of an individual to an organization that are provided in 2 CFR part 180, "OMB Guidelines to Agencies on Government-wide Debarment and Suspension (Non-procurement)." SUBCONTRACTOR must inform UM immediately of any information received from any source alleging a violation of a prohibition in paragraph 1 of this award term. UM right to terminate unilaterally as described in paragraph 2 (a) and (b) of this section under the U.S. Trafficking Victims Protection Act of 2000 (TVPA), as amended (22 U.S.C. 7104(g)), and ii. is in addition to all other remedies for noncompliance that are available to UM under this award.

3. SUBCONTRACTOR must include the requirements of paragraph a.1 of this award term in any SUBCONTRACT issued to a private entity pursuant to this agreement.

21. DISPUTES

The parties agree to use their best efforts to resolve any disagreement that arises out of this Agreement and to forward disagreements to others in their organization for resolution when necessary prior to seeking remedy by law.

22. GOVERNING LAW

This Agreement, and any disputes arising under it, shall be governed by and construed in accordance with the laws of the State of Maryland, which shall be the forum for any legal actions arising from or incident to this Agreement. Pending resolution of any dispute, SUBCONTRACTOR shall proceed diligently with the performance of its obligations under this Agreement.

23. ADMINISTRATIVE NOTICES

All notices or requests issued by the parties under this Agreement shall be directed to the Administrative Contacts named in Article IV. The parties agree that either or both may elect to conduct their transactions, execute, transmit, and store this agreement by electronic means including, but not limited to, facsimile, transmission to or by computer link, modem, or other electronic communication device. The parties agree that an electronic record or copy of this document shall be given the same accord as an executed original. Either party may also elect to conduct some or all transactions by non-electronic means.

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24. Consequential Damages

Notwithstanding anything to the contrary herewithin, neither party shall be liable to the other for consequential damages, including, without limitation, loss of use or loss of profits, incurred by one another or their subsidiaries or successors, regardless of whether such damages are caused by breach of contract, willful misconduct, negligent act or omission, or other wrongful act of either of them.

This Agreement shall not create any rights or benefits to parties other than SUBCONTRACTOR, UM and the Prime Sponsor. No other third party shall have the right to rely on SUBCONTRACTOR opinions rendered in connection with the services without the written consent of SUBCONTRACTOR and the third party's agreement to be bound to the same conditions and limitations as UM

25. ENTIRE SUBCONTRACT

This SUBCONTRACT represents the entire understandings of UM and SUBCONTRACTOR, and can only be modified in writing and duly executed by both parties.

FOR URS GROUP, INC.

By: 
(SUBCONTRACTOR's signature)
Name: J. Brian Jarboe
Title: Vice President
Date: 10-26-11

FOR UNIVERSITY OF MARYLAND

By: 
(UM's signature)
Name: Jill Frankenfield, Contract Manager
Title: Research Administration & Advancement
Date: 10/27/11

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Reporting of Total Compensation of Subrecipient Executives Appendix

The names and total compensation of the five most highly compensated officers of the entity(ies) must be listed if-- (i) the entity in the preceding fiscal year received— (I) 80 percent or more of its annual gross revenues in Federal awards (federal contracts (and subcontracts), loans, grants (and subgrants) and cooperative agreements); AND (II) \$25,000,000 or more in annual gross revenues from Federal awards; and (ii) the public does not have access to information about the compensation of the senior executives of the entity through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986.

If the SUBCONTRACT entity is not exempt from reporting executive compensation, complete the information below.

Officer 1 Name
Officer 1 Compensation

Officer 2 Name
Officer 2 Compensation

Officer 3 Name
Officer 3 Compensation

Officer 4 Name
Officer 4 Compensation

Officer 5 Name
Officer 5 Compensation

Appendix D – Copies of Equipment Purchase Receipts

INVOICE

Chesapeake Lighting
 9820 Patuxent Woods Drive
 Suite 200
 Columbia, MD 21046

Invoice Number: 2996
 Invoice Date: Oct 4, 2011
 Page: 1

Voice: (301) 953-2020
 Fax: (301) 953-0124

Duplicate

Bill To:
University Of Maryland Civil + Environmental Engineer 1173 Glenn Martin Hall College Park, MD 20742

Ship to:
University Of Maryland Civil + Environmental Engineer 1173 Glenn Martin Hall College Park, MD 20742

Customer ID	Customer PO	Payment Terms	
UNIVERSITY1	11-2086B	Net 30 Days	
Sales Rep ID	Shipping Method	Ship Date	Due Date
	Unknown	1/1/12	11/3/11

Quantity	Item	Description	Unit Price	Amount
6.00	Light Fixture Sales	Millerbernd 5' tapered sign support (dwg # 780B785) *Unfinished for lab testing purposes, tube per State of MD Hwy standard design, customer section specified ----- *Freight included *ASTM A1011 or A572 tapered steel tube for lab testing as sign supports. *1/4" X 10.0" X 9.3" X 5.0' with 2" thick connection plate, as per Millerbernd submittal drawing # 780B785 dated 7-19-2011.	755.00	4,530.00
Subtotal				4,530.00
Sales Tax				
Total Invoice Amount				4,530.00
Payment/Credit Applied				
TOTAL				4,530.00



Department of Procurement and Supply
0410 Service Building
College Park, MD 20742-6050

Date	11/30/11	Purchase Order	E157144
Effective Dates			
START	/ 0/	END	/ 0/

Terms	N 30	F.O.B	Solicitation No.	11/30/11	Delivery Date	11/15/11			
Purchasing Contact	Denise Elliott	Phone	301-405-3371	Requisition No.	R121913	Department Reference No.	*****	Vendor ID No.	B5209766560

Vendor	THRIFTY IRON WORKS INC 5627 LAFAYETTE PLACEQ HYATTSVILLE MD 20781	Ship To	UNIVERSITY OF MARYLAND CIVIL & ENVIRONMENTAL ENGR. MARTIN HALL ATTN: YUNFENG ZHANG COLLEGE PARK MD 20742
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Account Number	Percent	Amount	Account Number	Percent	Amount
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Item No.	Quantity	Unit	Description	Unit Price	Extension
001	1.00	LOT	Two Way Match A) FURNISH AND DELIVER MC12X50 CHANNELS (6) PER DRAWINGS ETC. B) FURNISH LABOR AND MATERIAIS TO FABRICATE TWO (2) COLUMNS USING YOUR MATERIAIS 01-7-77889-3914	8,100.00	8,100.00

Subject to the terms and conditions on both sides of this form, and its attachments, furnish goods and/or services described herein. See terms and conditions on reverse. Questions concerning this order should be directed to the Buyer:

Total \$ 8,100.00

By: Authorized Signature *Denise Elliott*

Date 11/30/11

Page No. 1

Send original invoice to:
University of Maryland
FM Accounting & Financial Support
1600 Service Building
College Park, MD 20742 301-405-3188

Include your **FEI number** or **Social Security** number on each invoice
Include the **purchase order number** on each invoice
University Tax Exempt Number: 30002563
Manufacturer s Federal Excise Tax Registration Number 52 730123K

Yunfeng Zhang
 University of Maryland
 Civil & Environmental Engineering
 1173 Glenn Martin Hall
 COLLEGE PARK, MD 20742
 UNITED STATES

Quotation Date: 28-NOV-2011
 Quote Valid Until: 28-DEC-2011
 Phone: (301) 405-1955
 Fax: 1301 452585
 Contact No: 5068460

Quotation No. 1613966

Please indicate the above quote number when ordering for faster processing.

Line No.	Qty.	Part Number	Description	List Price	Disc. %	Unit Price	Net Price
1	1	776975-35	LabVIEW Database Toolkit is a Set of High-Level Tools for Accessing Local and Remote Databases from LabVIEW. Connects to ODBC and OLE DB Databases through Microsoft ADO New Single Seat License(s) End User: Yunfeng Zhang Standard Delivery time: 5 - 10 business days ARO. Country of Origin: Ireland	\$ 999.00	75.00%	\$ 249.75	\$ 249.75
Sub-Total:				\$ 999.00	75.00%		\$ 249.75
Shipping and Handling:							\$ 17.63
Total:							\$ 267.38

Currency quoted in: U. S. Dollars

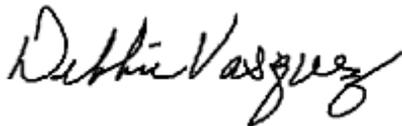
To ensure the highest quality service in order processing and support after delivery, please provide end-user information with your purchase order.

Additional Information:

- Payment Terms: Net 30
- Freight Terms: NI Weight Based Shipping

Unless expressly indicated by NI herein, all sales are subject to the enclosed National Instruments terms and conditions of quotation and sale. National Instruments shall not be bound by any conflicting or additional Terms and Conditions. Standard shipping dates are based on product availability at time of quotation and are subject to change without notice. Not all products produced by National Instruments are made in the U.S.A.

Yours sincerely,
National Instruments



Debbie Vasquez

Appendix D – Copies of Equipment Purchase Receipts Terms and Conditions of Sale

Customer and National Instruments ("NI") agree that the purchase and sales of NI hardware and software products ("the Products") and NI hardware and software services and support (the "Services") are made under these terms and conditions, and that NI SHALL NOT BE BOUND BY CUSTOMER'S ADDITIONAL OR DIFFERENT TERMS. Customer's order and purchase of the Products and Services shall constitute acceptance of these terms and conditions.

1. **TITLE.** Title to the Products shall pass at NI's plant. NI retains a security interest and right of possession in the Products until Customer makes full payment.
2. **TAXES.** Product prices are exclusive of, and Customer shall pay, applicable sales, use, service, value added or like taxes, unless Customer has provided NI with an appropriate exemption certificate for the delivery destination acceptable to the applicable taxing authorities.
3. **PRICES AND PAYMENT.** All quotations shall expire thirty (30) days from date of issuance, unless otherwise set forth on the quotation or agreed in writing. Customer shall make payment in full prior to or upon delivery by cashier's check, credit card, or money order, unless NI approves Customer for credit terms. If NI approves Customer's credit application, payment shall be due no later than 30 days from the date of NI's invoice. All sums not paid when due shall accrue interest daily at the lesser of a monthly rate of 1.5% or the highest rate permissible by law on the unpaid balance until paid in full. Except for Canada where payment shall be in Canadian Dollars, payments for orders accepted in the United States shall be made in U.S. Dollars. In the event of any order for several units, each unit(s) will be invoiced when shipped. Exceptions will be made for government purchase orders.
4. **ORDERS.** All orders are subject to acceptance by NI. NI's booking of an order shall constitute its acceptance of an order.
5. **DELIVERY.** NI shall deliver the Products to a carrier at NI's plant. Customer shall pay all applicable freight charges. On Products sold to Customers in the United States, Canada, and Mexico, NI shall prepay all freight charges and other necessary fees and shall bear the risks of carrying out customs formalities and clearance; NI will invoice the customer for applicable charges as shipping and handling fees. Orders are entered as close as possible to the Customer's requested shipment date, if any. Shipment dates are scheduled after acceptance of orders and receipt of necessary documents. Claims for shipment shortage shall be deemed waived unless presented to NI in writing within forty-five (45) days of shipment.
6. **LIMITED WARRANTY.** NI hardware Products are warranted against defects in materials and workmanship for one (1) year from the date NI ships the Products to Customer ("Delivery Date"). All software Products are licensed to Customer under the terms of the appropriate National Instruments license. For a period of ninety (90) days from the Delivery Date, NI software Products (when properly installed on NI hardware Products) (a) will perform substantially in accordance with the accompanying written materials, and (b) the medium on which the software product is recorded will be free from defects in materials and workmanship under normal use and service. Any replacement of a licensed software product will be warranted for the remainder of the original warranty period or thirty (30) days, whichever is longer. Customer must obtain a Return Material Authorization number from NI before returning any Products under warranty to NI. Customer shall pay expenses for shipment of repaired or replacement Products to and from NI. After examining and testing a returned product, if NI concludes that a returned product is not defective, Customer will be notified, the product returned at Customer's expense, and a charge made for examination and testing. This Limited Warranty is void if failure of the Products has resulted from accident, abuse, misapplication, modification, improper calibration by Customer, Customer supplied third party software not intended for use with the applicable NI software, utilization of an improper hardware or software key or unauthorized maintenance or repair.
7. **CUSTOMER REMEDIES.** NI's sole obligation (and Customer's sole remedy) with respect to the foregoing Limited Warranty shall be to, at its option, return the fees paid or repair/replace any defective Products, provided that NI receives written notice of such defects during the applicable warranty period. Customer may not bring an action to enforce its remedies under the foregoing Limited Warranty more than one (1) year after the accrual of such cause of action.
8. **RETURN/CANCELLATION/CHANGE POLICY.** Customer may return unwanted Products within thirty (30) days of the Delivery Date. Customer shall pay a fifteen percent (15%) restocking charge on any unwanted Products returned to NI. No returns will be accepted after the thirty (30) day period has expired. Where special equipment or services are involved, Customer shall be responsible for all related work in progress; however, NI shall take responsible steps to mitigate damages immediately upon receipt of a written cancellation notice from Customer. A Return-Material Authorization number must be obtained from NI for return of any Products. NI may terminate any order if any representations made by Customer to NI are false or misleading. Changes to orders shall not be binding upon nor be put into effect by NI unless confirmed in writing by NI's appropriate representative.
9. **NO OTHER WARRANTIES.** EXCEPT AS EXPRESSLY SET FORTH ABOVE, THE PRODUCTS ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, AND NO OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED ARE MADE WITH RESPECT TO THE PRODUCTS, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE OR NON-INFRINGEMENT OR ANY OTHER WARRANTIES THAT MAY ARISE FROM USAGE OF TRADE OR COURSE OF DEALING. NI DOES NOT WARRANT, GUARANTEE, OR MAKE ANY REPRESENTATIONS REGARDING THE USE OF OR THE RESULTS OF THE USE OF THE PRODUCTS IN TERMS OF CORRECTNESS, ACCURACY, RELIABILITY, OR OTHERWISE AND DOES NOT WARRANT THAT THE OPERATION OF THE PRODUCTS WILL BE UNINTERRUPTED OR ERROR FREE. NI EXPRESSLY DISCLAIMS ANY WARRANTIES NOT STATED HEREIN.
10. **NO LIABILITY FOR CONSEQUENTIAL DAMAGES.** The entire liability of NI and its licensors, distributors, and suppliers (including its and their directors, officers, employees, and agents) is set forth above. To the maximum extent permitted by applicable law, in no event shall NI and its licensors, distributors, and suppliers (including its and their directors, officers, employees, and agents) be liable for any damages, including, but not limited to, any special, direct, indirect, incidental, exemplary, or consequential damages, expenses, lost profits, lost savings, business interruption, lost business information, or any other damages arising out of the use or inability to use the Products, even if NI or its licensors, distributors, and suppliers has been advised of the possibility of such damages. Customer acknowledges that the applicable purchase price or license fee for the Products reflects this allocation of risk. Because some states/jurisdictions do not allow the exclusion or limitation of liability for consequential or incidental damages, the above limitation may not apply. If the foregoing limitation of liability is not enforceable because an NI product sold or licensed to Customer is determined by a court of competent jurisdiction in a final, non-appealable judgment to be defective and to have directly caused bodily injury, death, or property damage, in no event shall NI's liability for property damage exceed the greater of \$50,000 or fees paid for the specific product that caused such damage.
11. **WARNING:** (1) NI PRODUCTS ARE NOT DESIGNED WITH COMPONENTS AND TESTING FOR A LEVEL OF RELIABILITY SUITABLE FOR USE IN OR IN CONNECTION WITH SURGICAL IMPLANTS OR AS CRITICAL COMPONENTS IN ANY LIFE SUPPORT SYSTEMS WHOSE FAILURE TO PERFORM CAN REASONABLY BE EXPECTED TO CAUSE SIGNIFICANT INJURY TO A HUMAN. (2) IN ANY APPLICATION, INCLUDING THE ABOVE, RELIABILITY OF OPERATION OF THE SOFTWARE PRODUCTS CAN BE IMPAIRED BY ADVERSE FACTORS, INCLUDING BUT NOT LIMITED TO FLUCTUATIONS IN ELECTRICAL POWER SUPPLY, COMPUTER HARDWARE MALFUNCTIONS, COMPUTER OPERATING SYSTEM SOFTWARE FITNESS, FITNESS OF COMPILERS AND DEVELOPMENT SOFTWARE USED TO DEVELOP AN APPLICATION, INSTALLATION ERRORS, SOFTWARE AND HARDWARE COMPATIBILITY PROBLEMS, MALFUNCTIONS

OR FAILURES OF ELECTRONIC MONITORING OR CONTROL DEVICES, TRANSIENT FAILURES OF ELECTRONIC SYSTEMS (HARDWARE AND/OR SOFTWARE), UNANTICIPATED USES OR MISUSES, OR ERRORS ON THE PART OF THE USER OR APPLICATIONS DESIGNER (ADVERSE FACTORS SUCH AS THESE ARE HEREAFTER COLLECTIVELY TERMED "SYSTEM FAILURES"). ANY APPLICATION WHERE A SYSTEM FAILURE WOULD CREATE A RISK OF HARM TO PROPERTY OR PERSONS (INCLUDING THE RISK OF BODILY INJURY AND DEATH) SHOULD NOT BE RELIANT SOLELY UPON ONE FORM OF ELECTRONIC SYSTEM DUE TO THE RISK OF SYSTEM FAILURE. TO AVOID DAMAGE, INJURY, OR DEATH, THE USER OR APPLICATION DESIGNER MUST TAKE REASONABLY PRUDENT STEPS TO PROTECT AGAINST SYSTEM FAILURES, INCLUDING BUT NOT LIMITED TO BACK-UP OR SHUT DOWN MECHANISMS. BECAUSE EACH END-USER SYSTEM IS CUSTOMIZED AND DIFFERS FROM NI'S TESTING PLATFORMS AND BECAUSE A USER OR APPLICATION DESIGNER MAY USE NI PRODUCTS IN COMBINATION WITH OTHER PRODUCTS IN A MANNER NOT EVALUATED OR CONTEMPLATED BY NI, THE USER OR APPLICATION DESIGNER IS ULTIMATELY RESPONSIBLE FOR VERIFYING AND VALIDATING THE SUITABILITY OF NI PRODUCTS WHENEVER NI PRODUCTS ARE INCORPORATED IN A SYSTEM OR APPLICATION, INCLUDING, WITHOUT LIMITATION, THE APPROPRIATE DESIGN, PROCESS AND SAFETY LEVEL OF SUCH SYSTEM OR APPLICATION.

- 12. FORCE MAJEURE.** NI shall be excused for any delay or failure to perform due to any cause beyond its reasonable control, including but not limited to acts of governments, natural catastrophes, acts of Customer, interruptions of transportation or inability to obtain necessary labor or materials. NI's estimated shipping schedule shall be extended by a period of time equal to the time lost because of any excusable delay. In the event NI is unable to perform in whole or in part because of any excusable failure to perform, NI may cancel orders without liability to Customer.
- 13. LIMITED INDEMNITY AGAINST INFRINGEMENT.** NI shall, at its own expense, defend any litigation resulting from sales of the Products to the extent that such litigation alleges that the Products or any part thereof infringes any United States patent, copyright, or trademark, provided that such claim does not arise from the use of the Products in combination with equipment or devices not made by NI or from modification of the Products, and further provided that Customer notifies NI immediately upon its obtaining notice of such impending claim and cooperates fully with NI in preparing a defense. If Customer provides to NI the authority, assistance, and information NI needs to defend or settle such claim, NI shall pay any final award of damages in such suit and any expense Customer incurs at NI's written request, but NI shall not be liable for a settlement made without its prior written consent. If the Products are held to be infringing and the use thereof is enjoined, NI shall, at its option, either (i) procure for the Customer the right to use the Products, (ii) replace the Products with others which do not constitute infringement, or (iii) remove the infringing Products and refund the payment(s) made therefor by Customer. The foregoing states the Customer's sole remedy for, and NI's entire liability and responsibility for, infringement of any patent, trademark, or copyright relating to the Products provided hereunder. THIS LIMITED INDEMNITY IS IN LIEU OF ANY OTHER STATUTORY OR IMPLIED WARRANTY AGAINST INFRINGEMENT.
- 14. ACKNOWLEDGMENT/GOVERNING LAW.** Customer acknowledges reading these Terms and Conditions, understands them and agrees to be bound by them. A waiver of any provision of this agreement shall not be construed as a waiver or modification of any other term hereof. With respect to all orders accepted by NI in the United States, disputes arising in connection with these Terms and Conditions of Sale shall be governed by the laws of the State of Texas without regard to principles of conflicts of laws. With respect to all orders accepted by NI outside the United States, disputes arising in connection with these Terms and Conditions of Sale shall be governed by the laws of the country and locality in which NI accepts the order without regard to principles of conflicts of laws.
- 15. EEO COMPLIANCE.** As applicable, Customer shall comply with the following Equal Employment Opportunity requirements: 41 CFR sec 60-1.4(a), Equal Opportunity; 41 CFR sec 60-250.5, Equal Opportunity for Special Disabled Veterans and Veterans of the Vietnam Era; and 41 CFR sec. 60-741.5, Equal Opportunity for Workers with Disabilities.
- 16. SERVICES. Limited Warranty.** NI warrants that Services will be performed in a good and workmanlike manner. Except as expressly stated in the preceding sentence, NI makes no express or implied warranties with respect to the Services, including but not limited to (a) any warranty relating to third-party products or (b) any warranty concerning the results to be obtained from the Services or the results of any recommendation NI may make, including without limitation any implied warranties concerning the performance, merchantability, suitability, non-infringement or fitness for a particular purpose of any of the deliverables or of any system that may result from the implementation of any recommendation NI may provide. In order to receive warranty remedies, deficiencies in the Services must be reported to NI in writing within 90 days of completion of the Services. **Limitation of Liability.** NI is not liable for any incidental, indirect, special, or consequential damages arising out of or in connection with the Services provided by NI, including without limitation loss of use of the Products or any other software or data, including inability to achieve a particular result, even if NI has been advised of the possibility of such damages or even if the damage is the direct result of an instruction or suggestion made by NI. Except for claims that the Services caused bodily injury (including death), NI's total liability arising out of or in connection with any event or series of connected events occurring in connection with the Services shall not exceed the amount of fees paid under the separate written agreement between Customer and NI. These provisions allocate the risks under the separate written agreement between Customer and NI. NI's pricing reflects this allocation of risk and the limitation of liability specified herein. **High Risk Activities.** Customer understands and agrees that NI has not tested or certified its Services for use in high risk applications including medical life support, nuclear power, mass and air transportation control, or any other potentially life critical uses and makes no assurances that the Services are suitable for any high risk uses. **Indemnification.** Customer accepts responsibility for, and agrees to indemnify and hold NI harmless from, any and all liability, damages, claims, or proceedings arising out of (a) the failure of Customer to obtain the appropriate license, intellectual property rights, or any other permissions required to support any Products or NI's performance of the Services, including but not limited to, the right to make any copies or reproductions of any Customer-provided software or (b) any inaccurate representations regarding the existence of an export license or the eligibility for export of software or other materials without a license.
- 17. EXPORT LAWS.** The Products are subject to control under the U.S. Export Administration Regulations (15 CFR Part 730 *et. seq.*) and other applicable U.S. export control laws and regulations. Customer agrees that it will not export, re-export or transfer the Products via any means to any prohibited destination, entity or individual without the required export license(s) or authorization(s) from the U.S. Government. NI reserves the right not to ship the Products ordered if, at any time, NI believes that such shipment may violate U.S. export control laws.

Rev (07/23/2008)

SALES ORDER ACKNOWLEDGEMENT

Company : University of Maryland
 Contact : Charity McGee
 Fax Number :
 Sales Order No : 2324550
 Date : 06-SEP-11
 Customer Order No : MCGEE
 Terms : Credit card
 Currency : USD
 Quote Number : 1770451

BILL TO ADDRESS

University of Maryland
1173 Glenn Martin Hall
Charity McGee
College Park MD 20742
UNITED STATES

SHIP TO ADDRESS

University of Maryland
1173 Glenn Martin Hall
Charity McGee
College Park MD 20742
UNITED STATES

Part No.	Request Date	Schedule Ship Date	Order	List Price	Discount	Extended Price	
1.1	779373-01	06-SEP-11	08-SEP-11	1	529.00	10.00%	476.10
NI 9221 WITH DSUB 8-CHANNEL +/-60 V, 800 KS/S, 12-BIT ANALOG INPUT MODULE							
End User: Yunfeng Zhang							
Country of Origin : HUNGARY							
2.1	779473-01	06-SEP-11	08-SEP-11	1	49.00	10.00%	44.10
NI 9901 DESKTOP MOUNTING KIT							
End User: Yunfeng Zhang							
Country of Origin : USA							
3.1	780315-01	06-SEP-11	08-SEP-11	1	159.00	10.00%	143.10
RUGGED CARRYING CASE FOR PORTABLE INSTRUMENTATION							
End User: Yunfeng Zhang							
Country of Origin : USA							
4.1	763000-01	06-SEP-11	08-SEP-11	1	9.00	10.00%	8.10
POWER CORD,AC,U.S.,120VAC							
End User: Yunfeng Zhang							
Country of Origin : CHINA							
5.1	781157-01	06-SEP-11	08-SEP-11	1	699.00	10.00%	629.10
CDAQ-9174, COMPACTDAQ CHASSIS (4 SLOT USB)							
End User: Yunfeng Zhang							
Country of Origin : HUNGARY							
6.1	779994-01	06-SEP-11	08-SEP-11	1	1,499.00	10.00%	1,349.10
NI 9236 350 OHM, 8-CH, 24-BIT, 3.3VEX, 10KS/S, 1/4 BRIDGE INPUT MODULE							
End User: Yunfeng Zhang							
Country of Origin : HUNGARY							

If you have questions regarding your scheduled ship date or the date does not meet your needs, please contact us at 512-683-0100 or toll-free within the US/Canada at (800) 531-5066 and reference the Sales Order Number shown on page one of this acknowledgement.

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National Instruments Corp.
11500 N. MoPac Expwy
Austin, TX 78759-3504

Tel: (800) 531-5066
Fax: 512-683-8411

SALES ORDER ACKNOWLEDGEMENT

Company : University of Maryland
Contact : Charity McGee
Fax Number :
Sales Order No : 2324550
Date : 06-SEP-11
Customer Order No : MCGEE
Terms : Credit card
Currency : USD
Quote Number : 1770451

BILL TO ADDRESS

University of Maryland
1173 Glenn Martin Hall
Charity McGee
College Park MD 20742
UNITED STATES

SHIP TO ADDRESS

University of Maryland
1173 Glenn Martin Hall
Charity McGee
College Park MD 20742
UNITED STATES

Part No.	Request Date	Schedule Ship Date	Order	List Price	Discount	Extended Price
						Shipping and Handling: 47.48
						Subtotal: 2,697.08
						Total Tax: 0.00
						Final Tax will Reflect on your Billing Invoice
						Order Total: 2,697.08

If you have questions regarding your scheduled ship date or the date does not meet your needs, please contact us at 512-683-0100 or toll-free within the US/Canada at (800) 531-5066 and reference the Sales Order Number shown on page one of this acknowledgement.

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