CRC Proposal Abstract (updated 8/2010)

Investigator Name (Last name first):	SOBANJO, JOHN O.
Investigator Dept:	CIVIL AND ENVIRONMENTAL ENGINEERING
Title of Proposal:	Towards the Development of a Robotic System and Wireless Sensor Platform for Inspection and Monitoring of Submerged Bridge Substructures

Summary: *(must be kept to this one page; do not exceed one page; do not modify the document's margins or font size). Begin typing in the box below.* ***Word Limit is 250***.

The primary objective of this proposal is to complement an ongoing senior design project in an effort to develop a small-scale prototype of the robotic system and wireless sensor platform for monitoring of submerged bridge piles. The senior design project is a multidisciplinary effort between three departments at Florida State University: Civil and Environmental Engineering (CEE); Electrical and Computer Engineering (ECE); and Mechanical Engineering (ME). The senior design project is expected to have its first prototype version of the robotic system developed by April 2011. It is anticipated that starting in February 2011, CEE students will start constructing a test bed for the robotic system. The proposed test bed is a scaled model of a riverbed with bridge piles, and simulated scour conditions at the bottom of the "river." During the summer of 2011, the ME and ECE faculty and graduate students will then develop algorithms for post-processing of data to be collected by the robotic system. A revised and refined version of the prototype robotic system is expected by end of the summer 2011. The prototype robotic system will be installed at a local bridge to collect data on scour at the riverbed. Based on the preliminary results, proposals will be submitted to various agencies, including, the National Science Foundation (NSF) in October 2011. A trip is also planned, for two faculty members, to various sponsoring agencies in the Washington DC area, to visit and discuss with respective agencies regarding opportunities available for long-term monitoring of bridges.

Florida State University Sponsored Research
Budget Summary (gray boxes will automatically fill)

SOBANJO, JOHN O.	[leave blank]	
Principal Investigator	FSU Project ID	
FSU CRC 315	**[leave blank]**	2/1/2011 -- 1/31/2012
Sponsor	Sponsor Award No.	Award Period (dates as reflected in the RFP)

		Totals ($)
Section A, Senior/Key Person (PI, Co-PI) (Include fringe benefits)	6,000.00	
Section B, Other Personnel (Post Doc, GA, Technician, etc.) (Include fringe benefits)	11,240.00	
Total Salary, Wages and Fringe Benefits (A+B)		$17,240.00
Section C, Equipment		$6,500.00
Section D, Travel		$1,260.00
1. Domestic	1,260.00	
2. Foreign		
Section E, Other Direct Costs		$0.00
1. Tuition (GAs on payroll) **NOTE: CRC does NOT support tuition payment from CRC grants.**	**0.00**	
2. Materials and Supplies **(Equip is NOT a material or supply! Show any equip request in "Section C" above.)**		
3. Publication Costs		
4. Consultant Services		
5. ADP/Computer Services		
6. Subawards/Consortium/Contractual Costs		
7. Alterations and Renovations		
8. Rent		
9. Other 1:		
10. Other 2:		
11. Other 3:		
Section F, Participant/Trainee Support Costs (Not for PI expenses)		$0.00
1. Tuition (Training grants only. Non-payroll trainees.)		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other		
Section G, Direct Costs (A thru F)		$25,000.00
Section H, F&A Costs Rate: **0.00%** Base: ☐ MTDC ☐ TDC ☐ REU ☐ N/A		**$0.00**
Section I, Total Direct and F&A Costs (G + H)		$25,000.00

This form is a generic form, used for all CRC programs. However, not all of the categories within this form are allowable expenses under the various CRC programs. For example, FYAPs can only request support in Section A. Read the Budget section of the RFP to determine what types of expenses can be covered by the program from which you are requesting support. 8/2010

Use whole numbers only; no cents!

You are reminded the CRC requires complete detail of the above items in your proposal text, a section dedicated to the budget detail.

Approved By:

Signatures are NOT required as long as form is uploaded in the CRC system AND the Proposal Transmittal Form is fully signed.

Principal Investigator	Date			SRS Admin.	Date	SRS QA	Date
Chair	Date	Dean	Date	SRAS Project Setup	Date	SRAS Coord./Acct.	Date

FSU form No. 158 Rev. 03/18/2008 **Modified by Jtownsend 8/2010 for CRC purposes. Modifications shown in RED above.**

CRC Support Form (formerly Current & Pending) (updated 8/2010)

The following information must be provided for the Principal Investigator (PI) and co-PIs, if any, unless contra-indicated by rules inside the specific requests for proposals. We need to know what external grants (federal/state or other) you have that are current, what external grants (federal/state or other) you have applied for and the decision is pending, and in addition, the CRC wants to know what internal CRC or Cornerstone grants you have received in the past 5 years. Failure to provide this data may render your proposal ineligible.

Principal Investigator Name (last name first):	
☐ CHECK HERE IF YOU HAVE NOTHING TO REPORT AT THIS TIME.	

Investigator Name (Last Name First):	Sobanjo, John O.
Source of Support (Agency Name):	Florida Department of Transportation
Project Title *:	Development of Risk Models for Florida's Bridge Management System
	Support Status: X Current ☐ Pending ☐ Past
Total Award Amount:	$244,345
Total Award Period Covered:	7/8/2010 – 11/1/2012
Project Location:	Florida
Clarification Comments, if any:	

Investigator Name (Last Name First):	Sobanjo, John O.
Source of Support (Agency Name):	Florida Department of Transportation
Project Title *:	Enhancement of the FDOT's Project Level and Network Level Bridge Management
	Support Status: X Current ☐ Pending ☐ Past
Total Award Amount:	$240,000
Total Award Period Covered:	5/7/2008 – 2/28/2011
Project Location:	Florida
Clarification Comments, if any:	

Investigator Name (Last Name First):	DeBrunner, Victor
Source of Support (Agency Name):	Florida Department of Transportation
Project Title *:	Developing Low-Cost, Easily-Deployable Deflection Sensors
	Support Status: X Current ☐ Pending ☐ Past
Total Award Amount:	$12,278.90
Total Award Period Covered:	July 1, 2010 through June 30, 2011
Project Location:	Tallahassee, FL
Clarification Comments, if any:	

Investigator Name (Last Name First):	Clark, J.E.
Source of Support (Agency Name):	NSF
Project Title *:	Collaborative Research: Dynamics of Running on Variable Inclines
	Support Status: X Current ☐ Pending ☐ Past
Total Award Amount:	$ 122,000
Total Award Period Covered:	Sep 2008 – Aug 2011
Project Location:	FSU
Clarification Comments, if any:	

If more space is needed, copy and paste a blank of the last table (above) into the next page. Create a next page by adding ENTER spaces to the bottom of this form.

Investigator Name (Last Name First):	PI: Collins, E., co-PIs: Clark, J.E., and Oates, W.S.,
Source of Support (Agency Name):	Army Research Lab
Project Title *:	Collaborative Technology Alliance: Robotics
	Support Status: x Current □ Pending □ Past
Total Award Amount:	$ ~450,000/year
Total Award Period Covered:	Aug 2010- Dec 2014
Project Location:	FSU
Clarification Comments, if any:	

Investigator Name (Last Name First):	PI: Clark, J.E. co-PIs: Englander, O., Alvi, F., Oates, W.S., Shih, C., Collins, E.
Source of Support (Agency Name):	Air Force Research Lab
Project Title *:	Adaptive Robotic Multi-Modal Systems (ARM^2S
	Support Status: x Current □ Pending □ Past
Total Award Amount:	$ 143,000
Total Award Period Covered:	Sep 2010 – Aug 2011
Project Location:	FSU
Clarification Comments, if any:	

Investigator Name (Last Name First):	Roddenberry, Michelle
Source of Support (Agency Name):	Florida Department of Transportation
Project Title *:	Development of a Failure Theory for Concrete
	Support Status: x Current □ Pending □ Past
Total Award Amount:	$260,000.00
Total Award Period Covered:	09/22/2008 – 09/01/2011
Project Location:	
Clarification Comments, if any:	

Investigator Name (Last Name First):	Roddenberry, Michelle
Source of Support (Agency Name):	Florida Department of Transportation
Project Title *:	Design and Fabrication of Curved Precast U-Beam Bridges
	Support Status: x Current □ Pending □ Past
Total Award Amount:	$271,983.79
Total Award Period Covered:	03/04/2010 – 12/15/2012
Project Location:	
Clarification Comments, if any:	

Investigator Name (Last Name First):	Roddenberry, Michelle
Source of Support (Agency Name):	Florida Department of Transportation
Project Title *:	Development Device for Prestressing Strands in Beams
	Support Status: x Current □ Pending □ Past
Total Award Amount:	$8,835.34
Total Award Period Covered:	05/24/2010 – 06/30/2011
Project Location:	
Clarification Comments, if any:	

**If this project previously has been funded by another agency, please list agency name and furnish data for the funding period immediately preceding transfer.*

CRC/CS Vita Document (updated 8/2009)

Provide the following information for key personnel (PI and any co-PIs unless contraindicated by rules inside the specific request for proposals) on your proposal. Follow this format for each person. Do not exceed 2 pages per person. You may cut and paste into this document from other CV sources you may have on file, but adjust the font size to adhere to 11 pt. You may paste co-PI information in as new pages at the end of your document just so it is clear that the info is about any co-PI.

Principal Investigator*(Last name first)*: SOBANJO, JOHN O.

- **Education/Training** *(begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training)*

Institution & Location	Degree	Year/s	Field of Study
University of Lagos, Lagos, Nigeria	B.S.	1980	Civil Engineering
The University of Michigan, Ann Arbor, Michigan	M.S.E.	1984	Civil Engineering
Texas A&M University, College Station, Texas	Ph.D.	1991	Civil Engineering

- **Select pertinent portions of your current CV, in accordance with the RFP requirements, and insert that info below this line.**

RELEVANT EXPERIENCE HISTORY:

Associate Professor, Department of Civil Engineering**,** FAMU-FSU College of Engineering, Tallahassee, Florida, Aug. 2001 - Present.
Assistant Professor, Department of Civil Engineering**,** FAMU-FSU College of Engineering, Tallahassee, Florida, Aug. 1995 – July 2001.
Civil Engineer, California Department of Transportation, Sacramento, March 1993 - July 1995.
Civil, Engineer, California Department of Transportation, Los Angeles, June 1991 - Feb. 1993.
Civil Engineer, Texas State Department of Highways and Public Transportation, Lufkin, June 1986 - Aug. 1988.

PROFESSIONAL AFFILIATIONS, AWARDS, AND SERVICE:

Member, American Society of Civil Engineers (ASCE); Member, Design-Build Institute of America; Licensed Professional Engineer in California and Florida; Listed in the Who's Who in Science and Engineering, 2000, and Who's Who in the World 2003.

PUBLICATIONS:

1. Sobanjo John, Mtenga Primus, and Rambo-Roddenberry Michelle, (2010). "Reliability-Based Modeling of Bridge Deterioration Hazards," American Society of Civil Engineers, Journal of Bridge Engineering. Vol. 15, No. 6, pp. 671-683.
2. Tawfiq, Kamal, Mtenga Primus, and Sobanjo John, (2010). "Effect of Construction Induced Vibrations on Green Concrete in Drilled Shafts," American Society of Civil Engineers, Journal of Materials in Civil Engineering, Vol. 22, No. 6, pp. 637-642.
3. Sobanjo, John O., "State transition probabilities in bridge deterioration based on Weibull sojourn times," Journal of Structure and Infrastructure Engineering, Taylor & Francis, International Books and Journals, Oxford, United Kingdom, 2009.
4. Sobanjo, John O., Thompson, Paul, and Kerr, Richard, "Element-to-Component Translation of Bridge Condition Data," Transportation Research Record, Journal of Transportation Research Board (TRB), National Research Council, 2008, Paper No. 08-3149.
5. Sobanjo, J. O., Buxton-Tetteh Bernard, Ofosu Kwabena, Thompson Paul, Lewis Mathew, and Kerr Richard, "Simplified Queue Model for Estimating User Costs on Florida Moveable Bridges," Transportation Research Record, Journal of Transportation Research Board (TRB), National Research Council, January 2005, (Presentation).
6. Spainhour, Lisa, Wooton, Isaac, Sobanjo, John, and Brady Patrick, "Causative Factors and Trends in Florida Pedestrian Crashes," Transportation Research Record, Journal of Transportation Research Board (TRB) No. 1982, National Research Council, 2006, pp 90 – 98.
7. Sando, T., Mussa, R., Sobanjo, J., and Spainhour, L., "GPS Usability in Crash Location," Proceedings, 74th Annual Meeting of the Institute of Transportation Engineers, Orlando, Florida, 2004.

8. Haitao Wu, Thobias Sando, Renatus Mussa, John Sobanjo and Lisa Spainhour, "Integration of GPS and GIS to Improve Crash Location Data Accuracy," Proceedings, ESRI User Conference, 2004.
9. Thobias Sando, Renatus Mussa, Haitao Wu, John Sobanjo and Lisa Spainhour, "A Cost-Effective GIS Safety Analysis Tool for Improving Highway Safety," Proceedings, ESRI User Conference, 2004.
10. Thompson Paul, Sobanjo, J. O., and Kerr Richard, "Florida DOT Project Level Bridge Management Models," Journal of Bridge Engineering, American Society of Civil Engineers (ASCE), Nov. 2003.
11. Sobanjo, J. O., Thompson Paul, Lewis Mathew, and Kerr Richard, "Estimating Agency Cost of Maintenance, Repair & Rehabilitation (MR&R) for Florida Bridges," Transportation Research Record, Journal of Transportation Research Board (TRB), National Research Council, n 1795, 02-3772, 2002, p 66-73.
12. Tawfiq, K., Armaghani, J., and Sobanjo, J., "Rational method for selecting seismic waves for pavement evaluation," Journal of Transportation Engineering, American Society of Civil Engineers (ASCE), Nov-Dec 2002, v.128, 6, p550-558.
13. Sobanjo, John, "Integration of Supply Chains And Construction Schedule On Highway Projects," Proceedings, First International Conference on Construction in the 21st Century (CITC2002), "Challenges and Opportunities in Management and Technology," Miami, Florida, 2002, p221-228.
14. Sobanjo John, Thompson Paul, Lewis Mathew, and Kerr Richard, "Statistical Methodology For Estimating Agency Costs Of Bridge Maintenance, Repair, And Rehabilitation (MR&R)," Proceedings, First International Conference on Bridge Maintenance, Safety and Management (IABMAS), Barcelona, Spain, 2002.
15. Makola M. Abdullah, Jameel H. Hanif, Andy Richardson, and John Sobanjo, "Use of a shared tuned mass damper (STMD) to reduce vibration and pounding in adjacent structures," Earthquake Engineering & Structural Dynamics, Vol. 30, No 8, pp 1185-1201, 2001.
16. Sobanjo, John O., "Stochastic Models of Timing For Maintenance, Repair, And Rehabilitation (MR&R) Actions On Florida Bridges," Proceedings, Fifth NSF National Workshop On Bridge Research In Progress, University of Minnesota Minneapolis, Minnesota, 2001.
17. Tawfiq, K., Sobanjo, J., and Armaghani, J., "Curvilinear Behavior of Base Layer Moduli from Deflection and Seismic Methods," Transportation Research Record, Journal of Transportation Research Board (TRB), National Research Council, 2000, p 55-63.
18. Tawfiq, Kamal, Armaghani, Jamshid, and Sobanjo, J., "Seismic Pavement Analyzer vs. Falling Weight Deflectometer for Pavement Evaluation: Comparative Study*, Nondestructive Testing of Pavement and Backcalculation of Moduli, Third Volume, ASTM STP 3175,* S. D. Tayabji and E. O. Lukanen, Eds., American Society for Testing and Materials, West Conshohocken, PA, 2000, p 327 - 345.
19. Sobanjo, J. O., "Integrated Pavement-Bridge Management Under Uncertainty," Proceedings, 2nd International Workshop on Artificial Intelligence and Mathematical Methods in Pavement and Geomechnical Engineering Systems, University of Delaware, Aug, 2000, p 195 – 206.

RECENT FUNDED RESEARCH:

1. Development of Risk Models for Florida's Bridge Management System, Principal Investigator: Sobanjo John; Funded for $175,000, July 2010 – November 2012, Sponsored by the Florida Department of Transportation, Florida.
2. Enhancement of the FDOT's Project Level and Network Level Bridge Management, Principal Investigator: Sobanjo John; Funded for $175,000, May 2008 – February 2011, Sponsored by the Florida Department of Transportation, Florida.
3. Decision Support for Bridge Programming and Budgeting, Principal Investigator: Sobanjo John; Funded for $175,000, January 2005 – January 2007, Sponsored by the Florida Department of Transportation, Florida.
4. GPS/GIS Inspection and Analysis Tools for Highway Construction, Principal Investigator: Sobanjo John; Funded for $75,000, December 2004 – April 2006, Sponsored by the Florida Department of Transportation, Florida.
5. Project Planning Models for Bridge Management, Principal Investigator: Sobanjo John; Funded for $250,000, January 2001 – February 2004, Sponsored by the Florida Department of Transportation, Florida.
6. Design Guidelines for Highway Railroad Grade Crossing Profiles in Florida – Phase I, Principal Investigator: Sobanjo John; Funded for $106,000, September 2002 – October 2004, Sponsored by the Florida Department of Transportation, Florida.

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Principal Investigator*(Last name first)*:

• **Education/Training** *(begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training)*

Institution & Location	Degree	Year/s	Field of Study
Auburn University, Auburn, AL	B.E.E.	1984	Electrical Engineering
Virginia Polytechnic Institute and State University	M.S. E.E.	1986	Electrical Engineering
Virginia Polytechnic Institute and State University	Ph.D.	1990	Electrical Engineering

• Select pertinent portions of your current CV, in accordance with the RFP requirements, and insert that info below this line.

- Professor, Department of Electrical and Computer Engineering, FAMU-FSU College of Engineering, Florida State University, August 2006-present.
- Director, Dynamic Structures Sensing and Control (DySSC) Center, The University of Oklahoma, July 2001-July 2006. A research center combining faculty from Electrical and Computer Engineering, Aerospace and Mechanical Engineering, and Civil Engineering and Environmental Science.
- Professor: School of Electrical and Computer Engineering, The University of Oklahoma, July 1, 2001-July 2006. Named Kerr-McGee Presidential Professor, 2004.
- Associate Professor: School of Electrical and Computer Engineering, The University of Oklahoma, July 1, 1996-2001.
- Assistant Professor: School of Electrical and Computer Engineering, The University of Oklahoma, August 16, 1990-June 30, 1996.
- Honors:
  - Named Kerr-McGee Presidential Professor, The University of Oklahoma, 2005
  - United Nations Technical Exchange Expert in Telecommunications, Visitor to the People's Republic of China, 1997
  - Eta Kappa Nu (Electrical Engineering Honorary): inducted in 1982
  - Tau Beta Pi (Engineering Honorary): inducted in 1983
  - Phi Kappa Phi (Interdisciplinary Honorary): inducted in 1988
  - Phi Eta Sigma (Freshman Interdisciplinary Honorary): inducted in 1980
  - Pi Gamma Tau (Pre-Engineering Honorary): inducted in 1980

A. Selected peer-reviewed publications (in chronological order).

1. A. Medda and Victor DeBrunner, "Near-field Sub-band Beamforming for Damage Detection in Bridges," *Structural Health Monitoring*, vol. 8, no. 4, pp. 313-329, June 2009.
2. Y. Wang, L. DeBrunner, V. DeBrunner, and D. Zhou, "Blind Channel Equalization with Colored Source Based on Constrained Optimization Methods," *EURASIP Journal on Advances in Signal Processing*, vol. 2008, Article ID 960295, 9 pages, 2008. doi:10.1155/2008/960295.
3. Dayong Zhou and Victor DeBrunner, "A New Active Noise Control Algorithm that Requires No Secondary Path Identification Based on the SPR Property," *IEEE Transactions on Signal Processing*, vol. 55, Issue 5, Part 1, pp. 1719-1729, May 2007.

4. Dayong Zhou, Yunhua Wang, Victor DeBrunner and Linda S. DeBrunner, "Sub-band Implementation of Adaptive Nonlinear Filter for Adaptive Nonlinear Echo Cancellation," *Academy Publisher, Journal of Multimedia*, vol. 2, issue 2, pp. 77-82, April 2007.
5. Dayong Zhou and Victor DeBrunner, "Efficient adaptive nonlinear filters for nonlinear active noise control," *IEEE Transactions on Circuits and Systems – I: Fundamental Theory and Applications*, vol. 54, Issue 3, p. 669-681, March 2007.
6. Dayong Zhou and Victor DeBrunner, "Novel adaptive nonlinear predistorters based on the direct learning algorithm," *IEEE Transactions on Signal Processing*, vol. 55, no. 1, pp. 120-133, Jan. 2007.
7. Victor E. DeBrunner and Dayong Zhou, "Hybrid filtered error LMS algorithm: another alternative to filtered-x LMS," *IEEE Transactions on Circuits and Systems – I: Regular Papers*, pp. 653-661, March 2006.
8. V. E. DeBrunner, J. P. Havlicek, T. Przebinda, and M. Özaydın, "Entropy-based Uncertainty Measures for $L^2(\mathbb{R}^n)$, $\ell^2(\mathbb{Z})$, and $\ell^2(\mathbb{Z}/N\mathbb{Z})$ with a Hirschman Optimal Transform for $\ell^2(\mathbb{Z}/N\mathbb{Z})$," *IEEE Transactions on Signal Processing*, pp. 2690-2699, August 2005.
9. L. Wang, V. E. DeBrunner, and L. S. DeBrunner, "Sub-Band Adaptive Filtering with Delay Compensation for Active Control," *IEEE Transactions on Signal Processing*, pp. 2932-2937, October 2004.
10. V. Lakshmanan, R. Rabin, and V. E. DeBrunner, "Multiscale Storm Identification and Forecast," *Journal of Atmospheric Research*, Vol. 67-68, pp. 367-380, 2003.
11. V. E. DeBrunner, L. S. DeBrunner, S. Radhakrishnan and A. K. Khan, "The Telecomputing Laboratory: A Multi-Purpose Laboratory," *IEEE Transactions on Education,* Vol. 44, no. 4, pp. 302-310, November 2001.
12. T. Przebinda, V. E. DeBrunner, and M. Özaydın, "The Optimal Transform for the Discrete Hirschman Uncertainty Principle," *IEEE Transactions on Information Theory*, Vol. 47, no. 5, pp. 2086-2090, July 2001.
13. V. E. DeBrunner, M. Özaydın, and T. Przebinda, "Response to "Comments on 'Resolution in Time-Frequency," *IEEE Transactions on Signal Processing*, Vol. 48, no. 12, pp. 3586-3587, December 2000.
14. V. E. DeBrunner, L. S. DeBrunner, and L. Wang, "Robust Transmission of Block-Coded Still Images in Packet Switched Networks," *IEEE Communications Surveys,* Vol. 3, no. 1, First Quarter 2000. This peer-reviewed publication is archivable for at least 20 years at http://www.comsoc.org/pubs/surveys/ .
15. V. E. DeBrunner, M. Özaydın, and T. Przebinda, "Analysis in a Finite Time-Frequency Plane," *IEEE Transactions on Signal Processing*, Vol. 48, no. 6, pp. 1831-1832, June 2000.
16. V. E. DeBrunner and S. Torres, "Multiple Fully Adaptive Notch Filter Design Based on Allpass Sections," *IEEE Transactions on Signal Processing*, Vol. 48, no. 2, pp. 550-552, February 2000.

B. Research Support.

1. Co-investigator, Florida Department of Transportation, "Developing Low-Cost, Easily-Deployable Deflection Sensors," $12,280, July 2010-June 2011. With Michelle D. Roddenberry and Linda S. DeBrunner.
2. Co-investigator, Florida Department of Transportation, "Investigation of low-cost, easily-deployable deflection sensors," $15,000, December 2009-December 2010. With Michelle D. Roddenberry and Linda S. DeBrunner.
3. Co-investigator, Office of Naval Research, "Efficient DSP Hardware Implementations for Navy RF Systems," $340,000, January 2006-December 2009. "Pink Sheet" credit is 30%. With Linda S. DeBrunner, salary support.
4. Principal Investigator, Federal Highway Administration, "Intelligent Bridge System," $3,000,000, included for the Center for Structural Control at the University of Oklahoma in the FY'04 U.S. Budget, November 2004-December 2007. "Pink Sheet" credit is 30%. With David Baldwin, Linda DeBrunner, and Kyran Mish, salary support.
5. Co-investigator, National Science Foundation, "ITR: A Real Time Mining of Integrated Weather Data," $300,000, August 2002-July 2005 (extended for year 3), "Pink sheet" credit is 10%. With T. Trafalis, S. Lakshmivarahan, M. Richman, A. White, V. Lakshman, and P. Skubic, 1 month salary support.

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Principal Investigator*(Last name first)*:

• **Education/Training** *(begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training)*

Institution & Location	Degree	Year/s	Field of Study
Univ. Pennsylvania	Postdoc	04-07	Robotics
Stanford University	PhD, MS	88-04	Mechanical Engineering
Brigham Young University	BS	91-98	Mechanical Engineering

• Select pertinent portions of your current CV, in accordance with the RFP requirements, and insert that info below this line.

Professional Experience

9/04 – Current — Assistant Professor – Department of Mechanical Engineering, College of Engineering, Florida State University. Responsible for teaching undergraduate and graduate dynamics and robotics courses and research in robotic locomotion systems.

6/04 – 8/04 — Postdocotral Research – Ricoh Innovations, Inc. Responsible for the development and prototyping of innovative imaging systems.

Refereed Journal Articles Published – Related to Robot Design

Andrews, B., Miller, B., Schmitt, J. and Clark, J. "Running Over Unknown Rough Terrain with a One-Legged Planar Robot", Bioinspiration & Biomimetics – *under review*.

Kim, S., Clark, J. E. and Cutkosky, M. R., "iSprawl: Design and Tuning for High-Speed Autonomous Open-Loop Running." *International Journal of Robotics Research*, 25(9), pages 903-912, 2006

Cham, J.G., Bailey, S. A., Clark, J. E., Full, R. J. and Cutkosky, M. R., "Fast and Robust: Hexapedal Robots via Shape Deposition Manufacturing," *International Journal of Robotics Research*, Vol. 21(10), pages 869-882, 2002.

Refereed Papers Presented at Conferences and Symposia – Related to Robot Design

Shill, J., Miller, B., Schmitt, J., and Clark, J.E., "Design of a Dynamically Stable Horizontal Plane Runner," accepted for publication at IEEE International Conference on Robotics and Automation, Anchorage, Alaska, May 3 - 8, 2010.

Galloway, K., Clark, J.E., and Koditschek, D. E., "Design of a Tunable Stiffness Composite Leg for Dynamic Locomotion," Proceedings ASME IDETC 2009, Sand Diego, CA, Aug. 30-Sep. 2, 2009.

Sastra, J., Heredia, W.G.B., Clark, J.E., and Yim, M., "Biologically-Inspried Dynamic Legged Locomotion with a Modula Reconfigurable Robot," Proceedings ASME DSCC 2008, Ann Arbor, MI, October 20-22, 2008.

Galloway, K., Clark, J.E., and Koditschek, D. E., "Design of a Multi-Directional Variable Stiffness Leg for Dynamic Running," Proceedings ASME IMECE 2007, Seattle, WA, November 11-15, 2007.

Clark, J.E., Goldman, D. G., Lin, P. C., Lynch, G., Chen, T. S., Komsuoglu, H., Full, R. J., and Koditschek, D. E., "Design of a Bio-inspired Dynamical Vertical Climbing Robot," Robots: Science and Systems, Atlanta, GA, June 27-29, 2007.

Kim, S., Clark, J. E. and Cutkosky, M. R., "iSprawl: Autonomy, and the Effects of Power Transmission," 7th International Conference on Climbing and Walking Robots (CLAWAR 2004), Madrid, Spain, September 22-24, 2004. (International)

Cham, J. G., Karpick, J., Clark, J. E. and Cutkosky, M. R., "Stride Period Adaptation for a Biomimetic Running Hexapod," 10th International Symposium of Robotics Research, Lorne, Victoria, Australia, November 9-12, 2001. (International)

Clark, J. E., Cham, J. G., Bailey, S. A., Froelich, E. M., Nahata, P. K., Full, R. J. and Cutkosky, M. R., "Biomimetic Design and Fabrication of a Hexapedal Running Robot," Intl. Conf. Robotics and Automation (ICRA2001), Seoul, Korea, May 21-26, 2001. (International)

Contracts and Grants Funded

PI: Clark, J.E., "Bridging the Model/Reality Gap for Dynamic Legged Robots," Florida State University: First Year Assistant Professor Award, (Summer 2008), $16,000.

PI: Clark, J.E., "Survey of Robotic Approaches on Climbing," John Hopkins University/Applied Physics Lab, (Summer 2008), $35,000.

PI: Clark, J.E., "RIMS at NIMS," Leon County School Board, (Nov. 2008 – May. 2009), $16,000.

PI: Clark, J.E. and co-PI: Oates, W.S., "Biosynthesis of Aerodynamic Microsystems and Structures," Florida Center for Advanced Aero Propulsion, (Oct 2008 – Aug 2010), $117,000.

PI: Clark, J.E. "Collaborative Research: Dynamics of Running on Variable Inclines," National Science Foundation, (Sep 2008 – Aug 2011), $122,000.

PI: Clark, J.E "From Unstable Standing to Stable Walking," Procter and Gamble Education Outreach Grant (Jan 2009 – Dec 2011), $10,000.

PI: Clark, J.E. "PROficiency in and Appreciation of Mathematics and Science," Leon County School Board, (Feb 2010 - May 2010), $15,000.

PI: Collins, E., co-PIs: Clark, J.E., and Oates, W.S., "Collaborative Technology Alliance: Robotics", Army Research Lab, $450,000/year (5-10 years – local portion).

PI: Clark, J.E. co-PIs: Englander, O., Alvi, F., Oates, W.S., Shih, C., Collins, E. "Adaptive Robotic Multi-Modal Systems (ARM^2S)" Air Force Research Lab pre-proposal for the Campus Challenge, (Sep 2010 – Aug 2011), $150,000.

PI Name: SOBANJO, JOHN O.
Proposal Title: Towards the Development of a Robotic System and Wireless Sensor Platform for Inspection and Monitoring of Submerged Bridge Substructures
(Type proposal text below using Arial 11 Pt. Font provided)

1. Investigators

The United States' transportation infrastructure system is in a critical state of deterioration and services are being requested by various agencies for effective structural monitoring of our highway bridges. To address these needs, an application of advanced technology involving use of a robotic system and a wireless sensor platform is being proposed. Due to the complicated nature of the anticipated research on monitoring of bridges, a multidisciplinary research team has been formed here at Florida State University, between faculty from three different departments including Civil and Environmental Engineering (CEE), Electrical and Computer Engineering (ECE), and Mechanical Engineering (ME).

The CEE faculty will include the following:

1. Kamal Tawfiq, Ph.D., P.E., Professor and Chair
   Research Interests: Dynamic Characterization of Materials, Soil-Structure Interaction, and Non-Destructive Testing.
2. Primus Mtenga, Ph.D., P.E., Associate Professor
   Research Interests: Structural Systems, Condition Assessment, and Structural Retrofit.
3. John Sobanjo, Ph.D., P.E., Associate Professor
   Research Interests: Infrastructure Engineering and Management, Construction, GPS/GIS Applications.
4. Michelle Roddenberry, Ph.D., P.E., Assistant Professor
   Research Interests: Prestressed Concrete, Bridges, Structural Monitoring
5. Sungmoon Jung, Ph.D., Assistant Professor
   Research Interests: Structural Health Monitoring, Damage Identification, Wind Engineering, and Computational Intelligence.

The ECE faculty will include the following:

1. Victor DeBrunner, Ph.D., Professor
   Research Interests: Signal/Image Processing and Implementation, and Structural Health Monitoring.
2. Linda DeBrunner, Ph.D., Associate Professor
   Research Interests: Special Purpose Digital Hardware, Structural Health Monitoring, Digital Signal Processing and Implementations, and Fault Tolerant Computing.

The ME faculty will include the following:

1. Jonathan Clark, Ph.D., Associate Professor
   Research Interests: Robotic Design and Development, and Dynamics of Legged Locomotion.

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This team brings a spectrum of research backgrounds and experiences needed for the subject of long-term monitoring of bridges including prior research experience of bridge inspection, vibration-based monitoring of bridges, development of robotic systems, etc. The proposed research team has been meeting and discussing potential topics and response to Request for Proposals (RFPs). Some of these are described in the following sections, including a summary of recent efforts made to solicit funding from the National Institute of Standards and Technology (NIST), and the Florida Department of Transportation (FDOT). Also described is an ongoing multidisciplinary senior design project involving the three departments (CEE, ME, and ECE).

2. Proposed Program of Research

It has become a common knowledge that the nation's infrastructures are deteriorating at an alarming rate, exemplified by the recent collapse of the Minnesota I-35 bridge, in which 13 people lost their lives and several were seriously injured. Most of the nation's bridges are old, with need for detailed and long-term monitoring, to ensure safety of the public users. The U.S. Congress has reacted well by making available some research funds, through various agencies, to conduct studies into effective structural monitoring of the bridges. While faculty at Florida State University are very qualified to conduct such studies, there is a stiff competition nationwide for these funds. The nature of the studies also suggests a multi-disciplinary effort. First, civil and structural engineers best understand knowledge on the physical and engineering behavior of highway bridges. Secondly, the necessary use of robotic systems, complicated sensors and their networks for information and data management is best done by mechanical, electrical and electronic engineers.

2.1 Research background

Bridge scour has been attributed to cost millions of dollars in terms of bridge damage, human injuries and losses, and bridge maintenance and rehabilitation needs. The main danger of bridge scour is the undermining of piers and abutments, eliminating the support of bridge superstructure and causing catastrophic failure. Approximately 84 percent of the nation's 575,000 bridges in the National Bridge Inventory System (NBIS) span streams and rivers. One notable bridge failure is the collapse of Interstate-90 Bridge over Schoharie Creek, in New York State, in 1987. In this incident, five vehicles plunged into the creek as two spans of the bridge fell into the floodwaters, killing 10 people. Investigation into the collapse by the National Transportation Safety Board determined the cause of failure to be bridge scour. Also, about 67,000 bridges over the nation's waterways have their foundations classified as "unknown" thereby making it impossible to perform scour evaluations, with 144 of these bridges on the Interstate roadways.

Scour is defined as voids left behind when sediment is washed away from the bottom of the river. Local scour is the removal of sediments from around bridge piers or abutments. Contraction scour is removal of sediments from the bottom and sides of river channel while degradational scour is a more global removal of large amounts sediments from river bottom. Danger of scour is the undermining of bridge piers and abutments, eliminating the support of bridge superstructure and causing catastrophic failure.

The scour by itself undermines the substructure, threatening the bridge stability. Depending upon the severity, scour on piling may also reduce the friction resistance assumed for its load bearing capacity, as well as increase the "slenderness" of the piling as a structural member (Figure 1). The "point of fixity" may be shifted, increasing the vulnerability of the bridge pier to failure during unexpected or even designed impact by lateral loads.

The process of scour, particularly local scour, is very difficult to predict, as removal and deposition of soil sediments can occur during the same water flow, especially during high river currents. Previous research efforts based on the hydraulics and geotechnical characteristics are commendable but the scour phenomenon is complicated.

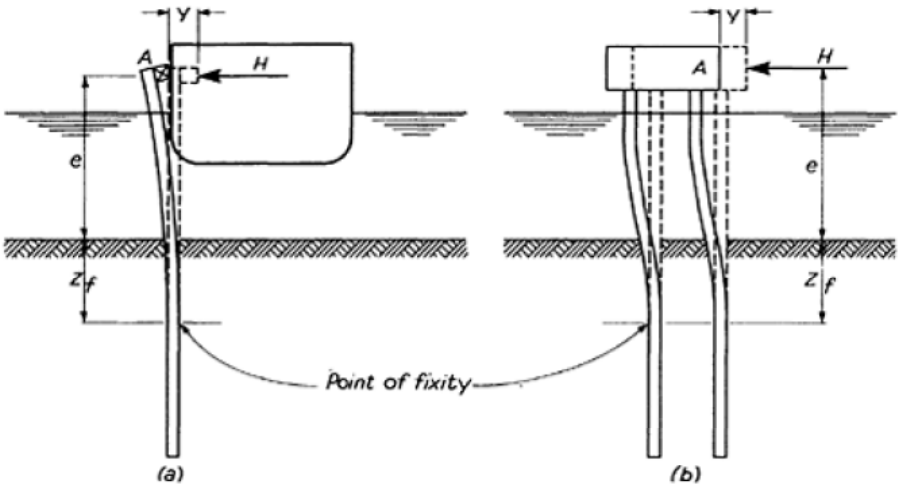

Figure 1. Lateral Movement of Fender Piles due to Impact Force from Berthing Ship, (a) Single Free-headed Pile (b) Group of Fixed-headed Piles

There is a tremendous challenge in modeling a 3D dimensional turbulent flow on a fragile riverbed soil, especially using laboratory-scaled models for the real site situations. Simply put, there are too many uncertainties. Thus, this research proposal will focus on physical measurement and monitoring of the scour. Monitoring the scour is very important in order to assess the stability of the bridge substructure, evaluate the structural integrity of the bridge, and also estimate the rehabilitation needs for the bridge.

Many reports have described the nationwide practice of bridge scour monitoring and also identified the shortcomings of the current technologies used. The state-of-the-art methods include fixed scour monitors, which are attached to the bridge element, including magnetic sliding collars, sonar monitors, and float-out devices (Figure 2). Tilt and vibration sensors are also sometimes employed to measure rotation and bridge movements.

(a) (b) (c)

Figure 2. Scour Monitoring Devices: (a) Active Sonar; (b) Sliding Magnetic Collar; and (c) Float-out Transmitter (Courtesy ETI Instruments Systems, Inc.)

Using soundings, the sonar systems determine the elevation of streambed near the piers. Sliding magnetic collars have built-in magnets that slide down a mast as the streambed erodes. Switches inside the mast are activated to indicate elevation within the scour area. Float-out devices are buried at scour-prone areas, that when scour occurs enough to release the device, a buoyant float-out element is released to the surface of the water.

As mentioned earlier, there are shortcomings with these technologies. First, a problem of debris accumulation was mentioned as affecting the fixed scour monitors. Second, the bridge owners stressed the need for improved technology that would increase durability and reliability, reduce costs, and require minimal maintenance. Also, currently, scour monitors, most of them fixed, measure scour depth at specific locations. New technology is needed to measure scour at various locations, including mapping the entire scour hole and identifying the deepest points. The monitoring of bridges located on tidal waterways also justifies the multi-location need of scour monitors, with regard to the ebb and flood tides. Finally, the integration of bridge scour monitoring systems with structural health monitoring is necessary as it may be beneficial in terms of cost reduction as well as bridge maintenance and safety concerns.

To address these concerns, an integrated platform of a robotic system and a wireless sensor network for required inspection and continuous monitoring of bridge substructures, with emphasis on the water-submerged sections. Despite some efforts in developing technologies for scour detection, visual inspection is still considered needed. But it is very difficult for divers to properly conduct underwater inspection due to poor visibility, river current, and other reasons. For scour inspection and monitoring, a robot is equipped with a sonar imaging system, a high-resolution video device, as well as lighting, and cleaning devices. Combined sonar and video imaging will result in effective structural monitoring and visual inspection.

Many techniques have been used to detect and measure scour, including radar, visual inspection, mechanical sounding rods, and sonar techniques. The mechanical sounding rod is basically using a rod to reach the bottom of the riverbed near the bridge pier. One of the initial drawbacks was that these methods were typically employed after a flood event, to estimate the scour depth or sediment deposit. Scour monitoring has been done using several methods including the use of Time Domain Reflectometry (TDR) and Fiber Optic Sensors. The drawback of these two methods is that the sensors are sacrificial and they have to be replaced after major flood events. In addition, the presence of debris threatens the operation of these sensors.

The sonar fathometer consists of both a sonar transducer and a receiver. The transducer emits a conical beam of sound waves, directed at the riverbed. With the sound speed in water known, the distance to the bottom can be computed based on the time for the sound wave emitted from the transducer to travel to the riverbed, to be reflected and received by the receiver. The sonar technique has proved to be a reliable and simple approach, based on estimating the distance between a fixed point on the bridge substructure and the riverbed near the bridge.

Discussions with Florida Department of Transportation (FDOT) bridge engineers suggest measuring scour widths typically less than 3 feet from the surface of the bridge pier or abutment. Proposed is a sonar-based device that will move to various locations around the base of the bridge pier and determine the location of the riverbed. This information will be interpreted through algorithms in the software into a mapping of the riverbed elevation below the bridge pier. Mapping of the 3D contour of elevations on the scour surface will be augmented with the high-resolution photographs, to improve the image precision. The sonar transducer will be set to emit waves at a very low cone angle and a suitable frequency (> 200 Hz) to achieve an excellent spatial resolution. While the sonar can collect data and transmit every second, the typical request of scour data is at about 15 minute intervals. Energy considerations also suggest not collecting data at high frequency except during flood events.

The proposed configuration is shown in Figure 3. A robotic system (“scour robot”) will house four devices: sonar fathometer; video camera; surface cleaner; and a lighting system. These devices will collect and transmit data wirelessly to a datalogger, with incorporated software, housed in a cabinet, which will be mounted outside the bridge railings on the deck. The datalogger will also have the ability to transmit the data collected to external locations such as the bridge engineer’s office. The novelty of the proposed system lies in the mobility of the inspection and monitoring devices through the use of the robot. There is no documented evidence of the application of wireless system of robotic sensors for underwater inspection or monitoring of bridge substructures. Mobility of scour measuring sensors avoids the debris problems and also enhances comprehensive mapping of scour holes.

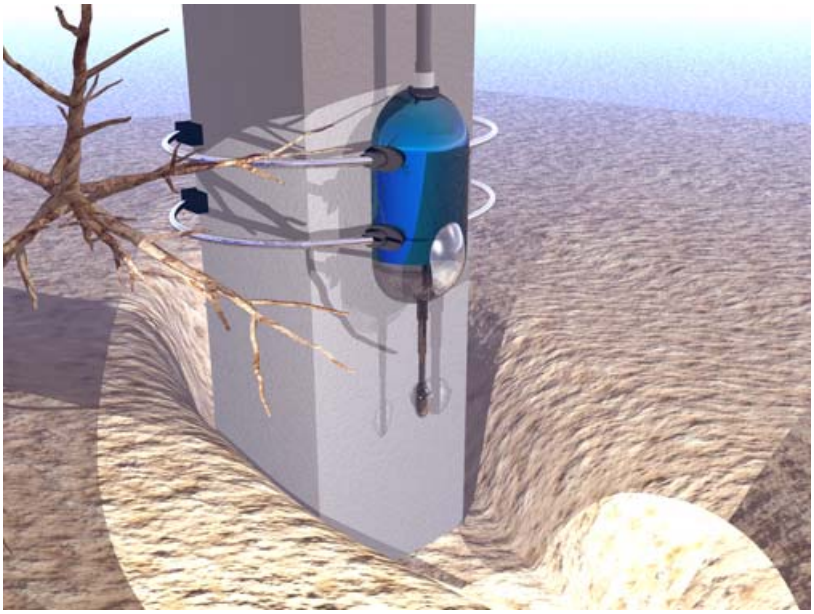

Figure 3. Close-up View of Proposed Robotic System for Scour Monitoring

3. Status of Research Group's Experience and Activities

The research team has been meeting frequently for the past two years. Since September 2008, the group has been meeting with and making presentations to bridge engineers at the Florida Department of Transportation. The first attempt of the group in getting external funding came in 2008 when an RFP was announced by FDOT for remote monitoring of bridges. Unfortunately, the RFP was cancelled two days before the proposal was to be submitted. Two formal proposals were prepared in 2009, one to the National Institute of Standards and Technology (NIST)'s Technology Innovation Program (TIP) and the other to the FDOT. The NIST proposal enabled the FSU research team to establish contacts with reputable industrial partners. The proposal was prepared and ready for submittal but there were problems of intellectual rights, which could not be resolved in time before the submittal deadline. The FDOT proposal was also not successful. It is believed that lessons learned from these proposals will be used to get better chances in the future.

4. Benefit of Proposed Activities

Due to the urgent need to monitor the structural condition of our transportation infrastructures, particularly highway bridges, many agencies are providing research funds to address this problem. To address this need, there is an ongoing alliance between three departments at Florida State University: the Department of Civil and Environmental Engineering (CEE); the Department of Electrical and Computer Engineering (ECE); and the Department of Mechanical Engineering (ME). The joint efforts of faculty in these units is currently being used to develop a research team for preparing proposals to generate external funding related to long term monitoring of highway bridges. Emphasis of the research team is now on the monitoring and inspection of bridge substructures, using a robotic system and wireless sensor platform. Efforts have been made in writing proposals to various agencies for external funding.

The Multi-Disciplinary Support is being solicited to facilitate primarily, development of a small-scale prototype of the robotic system and wireless sensor platform for monitoring of submerged bridge piles. Also planned is a limited travel to the potential sponsoring agencies, to enhance the future plan of our multidisciplinary research team at Florida State University.

5. Proposed Activities of The Research Group

The primary objective of the research being proposed is to complement the ongoing senior design project in an effort to develop a small-scale prototype of the robotic system and wireless sensor platform for monitoring of submerged bridge piles. The senior design project will enter its second and

final semester in January 2011, with the first prototype version of the robotic system expected to be developed by April 2011. It is anticipated that starting in February 2011, CEE students will starting constructing a test bed for the robotic system. The proposed test bed is a scaled model of a riverbed with bridge piles, and simulated scour conditions at the bottom of the "river." During the summer of 2011, the ME and ECE faculty and graduate students will then develop algorithms for post-processing of data to be collected by the robotic system. A revised and refined version of the prototype robotic system is expected by end of the summer 2011. Preliminary data will be collected at the test bed and analyzed, and further refinements will be done as necessary to the system.

Between September and December 2011, the prototype robotic system will be installed at a local bridge to collect data on scour at the riverbed. Based on the preliminary results, a proposal will be submitted to the National Science Foundation (NSF) Infrastructure Research Program in October 2011. A trip is also planned, for two faculty members, to various sponsoring agencies in the Washington DC area, to visit and discuss with respective program managers and US Congressional staffers, the specific opportunities available for long-term monitoring of bridges.

The sponsoring agencies that will be targeted for future proposals include:

- National Institute of Standards and Technology (NIST) – Technology Innovation Program (TIP)
- National Science Foundation (NSF) – The Resilient and Sustainable Infrastructures Cluster Program
- National Cooperative Highway Research Program (NCHRP) – Innovations Deserving Exploratory Analysis (IDEA)
- Federal Highway Administration (FHWA) – Long-Term Bridge Performance Program (LTBPP)

The above programs are discussed in more detail in Section 6.

6. Availability of External Sources of Support

Many sponsoring agencies are targeted for proposals but a few of them are described as follows:

- The National Institute of Standards and Technology (NIST)'s Technology Innovation Program (TIP):

  The TIP is sponsored and administered by NIST, based in Gaithersburg, Maryland. The TIP was established for support of research by businesses and universities, in areas such as recently advertised in 2009, for the use of advanced sensing technologies for infrastructure, including roads, highways, bridges, and water. The primary goal of TIP is to support and promote innovative research that is high-risk and high-reward in nature.

  Request for Proposals (RFP) are issued annually in the summer. The research team plans to submit a proposal around summer 2011.

- National Science Foundation (NSF): The Resilient and Sustainable Infrastructures Cluster Program:
  - This program supports research to advance fundamental knowledge and innovation for resilient and sustainable civil infrastructure and distributed infrastructure networks. The Cluster funds research on geotechnical, structural, and earthquake engineering, distributed infrastructure systems management and response to hazardous events. Funded under this program are the following programs: Civil Infrastructure Systems (CIS); Hazard Mitigation and Structural Engineering (HMSE); and the Infrastructure Management and Extreme Events (IMEE).

  Request for Proposals (RFP) are issued twice a year. The research team plans to submit a proposal in October 2011.

- The National Cooperative Highway Research Program's Innovations Deserving Exploratory Analysis (NCHRP-IDEA):

  National Cooperative Highway Research Program, Transportation Research Board, 500 Fifth Street, NW, Washington, DC. This program seeks to introduce new technologies, methods, or processes for application to highways and intermodal surface transportation through the

development and testing of nontraditional and innovative concepts, including application of those from other technology sectors that have not yet been tested in the highway sector. IDEA concepts should have one or more of the following features: Engineering and scientific innovations that offer significant promise for development into usable and cost-effective technologies, processes, or products; High-risk but credible technical concepts that offer potential for significant technological breakthroughs and large payoffs; New concepts that offer the potential for advancing the state-of-the-art highway and intermodal surface transportation technologies or those that may emerge into new technology areas for highway application; Advanced concepts and products developed for other engineering applications but not as yet tested or applied to highway practice; and Advanced technologies tested or used in overseas practice but as yet not tested or proven useful in U.S. practice.
Request for Proposals (RFP) are issued twice a year. The research team plans to submit a proposal in September 2011.

- Federal Highway Administration (FHWA): The Long-Term Bridge Performance Program (LTBPP):
  Located at the Turner-Fairbank Highway Research Center, McLean, Virginia, the FHWA initiated the LTBPP in 2006 with the objective of improving knowledge regarding bridge performance over a long period of time. The program will instrument, monitor, and evaluate a large number of bridges throughout the United States in order to capture performance data over a 20-year period of time and, on the basis of the information collected from these structures, provide significantly improved life-cycle cost and performance and predictive models that can be used for bridge and asset-management decision-making. The LTBP program will also conduct forensic investigations on decommissioned bridges, as the opportunity arises.
  Request for Proposals (RFP) are issued based on fund availability. The research team plans to submit a proposal if any RFP is issued in 2011.

7. Keywords for Electronic Searches
Bridges, Remote monitoring, bridge deterioration, scour, substructures, and sensors.

8. Permission to Use Proposal
The proposers hereby grant permission to FSU to use this proposal as an example of an awarded format in the event it is funded.

9. Documents
Documents, such as Animal Use Form and Human Subjects Approval, are not applicable to the planned research.

10. Budget
The amount of $25,000 is being requested under this proposal, primarily to cover the costs of developing and testing the proposed prototype robotic system, and also $1,260 of travel costs to visit the agencies as described above. A detailed budget is presented in the following table.

Table 1. Detailed Budget

	ITEM DESCRIPTION	COST
1	Faculty (2) and Graduate Students (2) from ME and ECE Departments to develop algorithms for post-processing of data collected by proposed robotic system, and also refining the system. Estimated costs are $6,000 for ME and $6,000 for ECE. Equipment cost for robotic system estimated as $6,500.	$18,500
2	Faculty (1) and Graduate Students (2) from CEE Department design and construct a testbed for bridge pile and scour riverbed, including materials and equipment. Preliminary analyses of scour data. Estimated cost is $5,240.	$5,240
3	Faculty (2) travel to Washington DC to meet potential sponsors on research related to infrastructure health monitoring, for two-day trip (two nights): Airline flight ticket ($450/person); Hotel ($120/person/day); Per Diem ($36/day/person); and Rental car ($48/day).	$1,260
TOTAL ESTIMATED COST		**$25,000**