

Final Progress Report for Research Projects Funded by Health Research Grants

Instructions: Please complete all of the items as instructed. Do not delete instructions. Do not leave any items blank; responses must be provided for all items. If your response to an item is “None”, please specify “None” as your response. “Not applicable” is not an acceptable response for any of the items. There is no limit to the length of your response to any question. Responses should be single-spaced, no smaller than 12-point type. The report **must be completed using MS Word**. Submitted reports must be Word documents; they should not be converted to pdf format. Questions? Contact Health Research Program staff at 717-783-2548.

1. **Grantee Institution:** The Trustees of the University of Pennsylvania
2. **Reporting Period (start and end date of grant award period):** 1/1/2009-12/31/2012
3. **Grant Contact Person (First Name, M.I., Last Name, Degrees):** Gearline R. Robinson-Hall, BSF
4. **Grant Contact Person’s Telephone Number:** 215-746-6821
5. **Grant SAP Number:** 4100047654
6. **Project Number and Title of Research Project:** 2 - Nanofabrication Lab for Biosensors and Biomeasurements – Research Infrastructure
7. **Start and End Date of Research Project:** 1/1/2009-10/1/2010
8. **Name of Principal Investigator for the Research Project:** George J. Pappas, PhD
9. **Research Project Expenses.**

9(A) Please provide the total amount of health research grant funds spent on this project for the entire duration of the grant, including indirect costs and any interest earned that was spent:

\$ 500,000

9(B) Provide the last names (include first initial if multiple individuals with the same last name are listed) of **all** persons who worked on this research project and were supported with health research funds. Include position titles (Principal Investigator, Graduate Assistant, Post-doctoral Fellow, etc.), percent of effort on project and total health research funds expended for the position. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name	Position Title	% of Effort on Project	Cost
None			

9(C) Provide the names of **all** persons who worked on this research project, but who *were not* supported with health research funds. Include position titles (Research Assistant, Administrative Assistant, etc.) and percent of effort on project. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name	Position Title	% of Effort on Project
Pappas	Professor	<1%

9(D) Provide a list of **all** scientific equipment purchased as part of this research grant, a short description of the value (benefit) derived by the institution from this equipment, and the cost of the equipment.

Type of Scientific Equipment	Value Derived	Cost
None		

10. Co-funding of Research Project during Health Research Grant Award Period. Did this research project receive funding from any other source during the project period when it was supported by the health research grant?

Yes No

If yes, please indicate the source and amount of other funds:

Penn Unrestricted Funds \$1.6M

11. Leveraging of Additional Funds

11(A) As a result of the health research funds provided for this research project, were you able to apply for and/or obtain funding from other sources to continue or expand the research?

Yes No

If yes, please list the applications submitted (column A), the funding agency (National Institutes of Health—NIH, or other source in column B), the month and year when the application was submitted (column C), and the amount of funds requested (column D). If you have received a notice that the grant will be funded, please indicate the amount of funds to be awarded (column E). If the grant was not funded, insert “not funded” in column E.

Do not include funding from your own institution or from CURE (tobacco settlement funds). Do not include grants submitted prior to the start date of the grant as shown in Question 2. If you list grants submitted within 1-6 months of the start date of this grant, add a statement below the table indicating how the data/results from this project were used to secure that grant.

A. Title of research project on grant application	B. Funding agency (check those that apply)	C. Month and Year Submitted	D. Amount of funds requested:	E. Amount of funds to be awarded:
None	<input type="checkbox"/> NIH <input type="checkbox"/> Other federal (specify: _____) <input type="checkbox"/> Nonfederal source (specify: _)		\$	\$

11(B) Are you planning to apply for additional funding in the future to continue or expand the research?

Yes _____ No X _____

If yes, please describe your plans:

12. Future of Research Project. What are the future plans for this research project?

Project is complete.

13. New Investigator Training and Development. Did students participate in project supported internships or graduate or post-graduate training for at least one semester or one summer?

Yes _____ No X _____

If yes, how many students? Please specify in the tables below:

	Undergraduate	Masters	Pre-doc	Post-doc
Male				
Female				
Unknown				
Total				

	Undergraduate	Masters	Pre-doc	Post-doc
Hispanic				
Non-Hispanic				
Unknown				
Total				

	Undergraduate	Masters	Pre-doc	Post-doc
White				
Black				
Asian				
Other				
Unknown				
Total				

14. Recruitment of Out-of-State Researchers. Did you bring researchers into Pennsylvania to carry out this research project?

Yes _____ No X _____

If yes, please list the name and degree of each researcher and his/her previous affiliation:

15. Impact on Research Capacity and Quality. Did the health research project enhance the quality and/or capacity of research at your institution?

Yes X _____ No _____

If yes, describe how improvements in infrastructure, the addition of new investigators, and other resources have led to more and better research.

Penn faculty members who have started using the Nanofabrication Facility since the upgrade include Kevin Turner, David Issadore, Brian Chow, Igor Bargatin and Ertugrul Cubukcu from Penn Engineering; Zahra Fakhraai and Arjun Yodh from Penn Arts & Sciences; Jay Dorsey and Douglas Smith from Penn's Perelman School of Medicine; and Jonathan Spanier, Roberto Ramos and Afshin Drayoush from Drexel University. These new faculty members using the upgraded facility have established new collaborations among the researchers resulting in new funding proposals and awards.

16. Collaboration, business and community involvement.

16(A) Did the health research funds lead to collaboration with research partners outside of your institution (e.g., entire university, entire hospital system)?

Yes _____ No X _____

If yes, please describe the collaborations:

16(B) Did the research project result in commercial development of any research products?

Yes _____ No X _____

If yes, please describe commercial development activities that resulted from the research project:

16(C) Did the research lead to new involvement with the community?

Yes _____ No X _____

If yes, please describe involvement with community groups that resulted from the research project:

17. Progress in Achieving Research Goals, Objectives and Aims.

List the project goals, objectives and specific aims (as contained in the grant agreement). Summarize the progress made in achieving these goals, objectives and aims for the period that the project was funded (i.e., from project start date through end date). Indicate whether or not each goal/objective/aim was achieved; if something was not achieved, note the reasons why. Describe the methods used. If changes were made to the research goals/objectives/aims, methods, design or timeline since the original grant application was submitted, please describe the changes. Provide detailed results of the project. Include evidence of the data that was generated and analyzed, and provide tables, graphs, and figures of the data. List published abstracts, poster presentations and scientific meeting presentations at the end of the summary of progress; peer-reviewed publications should be listed under item 20.

This response should be a DETAILED report of the methods and findings. It is not sufficient to state that the work was completed. Insufficient information may result in an unfavorable performance review, which may jeopardize future funding. If research findings are pending publication you must still include enough detail for the expert peer reviewers to evaluate the progress during the course of the project.

Health research grants funded under the Tobacco Settlement Act will be evaluated via a performance review by an expert panel of researchers and clinicians who will assess project work using this Final Progress Report, all project Annual Reports and the project's strategic plan. After the final performance review of each project is complete, approximately 12-16 months after the end of the grant, this Final Progress Report, as well as the Final Performance Review Report containing the comments of the expert review panel, and the grantee's written response to the Final Performance Review Report, will be posted on the CURE Web site.

There is no limit to the length of your response. Responses must be single-spaced below, no smaller than 12-point type. If you cut and paste text from a publication, be sure symbols print properly, e.g., the Greek symbol for alpha (α) and beta (β) should not print as boxes (\square) and include the appropriate citation(s). DO NOT DELETE THESE INSTRUCTIONS.

Nanotechnology includes a wide range of technologies that measure, manipulate or incorporate materials and/or features with at least one dimension between 1 and 100 nanometers (nm). At these scales reside the basic biology, chemistry and physics that govern chemical and biochemical reactions. Understanding what happens inside cells is critical to prevention, detection and treatment of disease. Experiments in nanotechnology are done inside wet laboratories with chemical fume hoods and in spaces designed to accommodate multiple large pieces of complex, sensitive equipment. Such facilities rank among the most expensive structures a university can construct.

Improvements to the Wolf Nanofabrication Facility, including a 50% expansion of the cleanroom space, will enable researchers to do many different types of experiments in the future. One of the first devices which will be built using the Facility will be a prostate cancer detector, built from carbon nanotube transistors. Another device will be a sensor which will be used to map biological and chemical signals in the brain, using nanowires. This will provide a vital platform to understanding the fundamental origins and causes of neurological diseases, ultimately aimed at effective prevention and long-term treatment. Other nanowire devices will be built to detect individual molecules which are indicators of disease. These and many other experiments will be conducted at the University of Pennsylvania, leading to research publications and patents for medical devices of the future.

Specific measures:

Renovation and occupation of the space - lab is renovated & fully occupied

Numbers of investigators supported - 40

Numbers of projects supported - 78

External grants supported – 64

Improvements to the Wolf Nanofabrication Facility include the following new features: improved air handling system for the lithography room, toxic gas monitoring system, gas piping for utility nitrogen and clean dry air, floor treatment, wall treatment, new ceiling, new lights, sprinklers for fire suppression and process cooling water loop.

The renovated space is 3,500 sq ft, which includes a 1,950 sq ft class 1,000 (ISO 6) cleanroom and associate support spaces.

18. Extent of Clinical Activities Initiated and Completed. Items 18(A) and 18(B) should be completed for all research projects. If the project was restricted to secondary analysis of clinical data or data analysis of clinical research, then responses to 18(A) and 18(B) should be “No.”

18(A) Did you initiate a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

Yes

No

18(B) Did you complete a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

Yes

No

If “Yes” to either 18(A) or 18(B), items 18(C) – (F) must also be completed. (Do NOT complete 18(C-F) if 18(A) and 18(B) are both “No.”)

18(C) How many hospital and health care professionals were involved in the research project?

_____ Number of hospital and health care professionals involved in the research project

18(D) How many subjects were included in the study compared to targeted goals?

_____ Number of subjects originally targeted to be included in the study

_____ Number of subjects enrolled in the study

Note: Studies that fall dramatically short on recruitment are encouraged to provide the details of their recruitment efforts in Item 17, Progress in Achieving Research Goals, Objectives and Aims. For example, the number of eligible subjects approached, the number that refused to participate and the reasons for refusal. Without this information it is difficult to discern whether eligibility criteria were too restrictive or the study simply did not appeal to subjects.

18(E) How many subjects were enrolled in the study by gender, ethnicity and race?

Gender:

_____ Males

_____ Females

_____ Unknown

Ethnicity:

_____ Latinos or Hispanics

_____ Not Latinos or Hispanics

_____ Unknown

Race:

_____ American Indian or Alaska Native

_____ Asian

_____ Blacks or African American

_____ Native Hawaiian or Other Pacific Islander

_____ White

_____ Other, specify: _____

_____ Unknown

18(F) Where was the research study conducted? (List the county where the research study was conducted. If the treatment, prevention and diagnostic tests were offered in more than one county, list all of the counties where the research study was conducted.)

19. Human Embryonic Stem Cell Research. Item 19(A) should be completed for all research projects. If the research project involved human embryonic stem cells, items 19(B) and 19(C) must also be completed.

19(A) Did this project involve, in any capacity, human embryonic stem cells?

Yes
 No

19(B) Were these stem cell lines NIH-approved lines that were derived outside of Pennsylvania?

Yes
 No

19(C) Please describe how this project involved human embryonic stem cells:

20. Articles Submitted to Peer-Reviewed Publications.

20(A) Identify all publications that resulted from the research performed during the funding period and that have been submitted to peer-reviewed publications. Do not list journal abstracts or presentations at professional meetings; abstract and meeting presentations should be listed at the end of item 17. **Include only those publications that acknowledge the Pennsylvania Department of Health as a funding source** (as required in the grant agreement). List the title of the journal article, the authors, the name of the peer-reviewed publication, the month and year when it was submitted, and the status of publication (submitted for publication, accepted for publication or published.). Submit an electronic copy of each publication or paper submitted for publication, listed in the table, in a PDF version 5.0.5 (or greater) format, 1,200 dpi. Filenames for each publication should include the number of the research project, the last name of the PI, the number of the publication and an abbreviated research project title. For example, if you submit two publications for PI Smith for the “Cognition and MRI in Older Adults” research project (Project 1), and two publications for PI Zhang for the “Lung Cancer” research project (Project 3), the filenames should be:

- Project 1 – Smith – Publication 1 – Cognition and MRI
- Project 1 – Smith – Publication 2 – Cognition and MRI
- Project 3 – Zhang – Publication 1 – Lung Cancer
- Project 3 – Zhang – Publication 2 – Lung Cancer

If the publication is not available electronically, provide 5 paper copies of the publication.

Note: The grant agreement requires that recipients acknowledge the Pennsylvania

Department of Health funding in all publications. Please ensure that all publications listed acknowledge the Department of Health funding. If a publication does not acknowledge the funding from the Commonwealth, do not list the publication.

Title of Journal Article:	Authors:	Name of Peer-reviewed Publication:	Month and Year Submitted:	Publication Status (check appropriate box below):
1. None				<input type="checkbox"/> Submitted <input type="checkbox"/> Accepted <input type="checkbox"/> Published

20(B) Based on this project, are you planning to submit articles to peer-reviewed publications in the future?

Yes _____ No X

If yes, please describe your plans:

21. Changes in Outcome, Impact and Effectiveness Attributable to the Research Project.

Describe the outcome, impact, and effectiveness of the research project by summarizing its impact on the incidence of disease, death from disease, stage of disease at time of diagnosis, or other relevant measures of outcome, impact or effectiveness of the research project. If there were no changes, insert “None”; do not use “Not applicable.” Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

22. Major Discoveries, New Drugs, and New Approaches for Prevention Diagnosis and Treatment.

Describe major discoveries, new drugs, and new approaches for prevention, diagnosis and treatment that are attributable to the completed research project. If there were no major discoveries, drugs or approaches, insert “None”; do not use “Not applicable.” Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

23. Inventions, Patents and Commercial Development Opportunities.

23(A) Were any inventions, which may be patentable or otherwise protectable under Title 35 of the United States Code, conceived or first actually reduced to practice in the performance of work under this health research grant? Yes _____ No X

If “Yes” to 23(A), complete items a – g below for each invention. (Do NOT complete items

a - g if 23(A) is "No.")

- a. Title of Invention:
- b. Name of Inventor(s):
- c. Technical Description of Invention (describe nature, purpose, operation and physical, chemical, biological or electrical characteristics of the invention):
- d. Was a patent filed for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No_____

If yes, indicate date patent was filed:

- e. Was a patent issued for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No_____

If yes, indicate number of patent, title and date issued:

Patent number:

Title of patent:

Date issued:

- f. Were any licenses granted for the patent obtained as a result of work performed under this health research grant? Yes_____ No_____

If yes, how many licenses were granted?_____

- g. Were any commercial development activities taken to develop the invention into a commercial product or service for manufacture or sale? Yes___ No___

If yes, describe the commercial development activities:

23(B) Based on the results of this project, are you planning to file for any licenses or patents, or undertake any commercial development opportunities in the future?

Yes_____ No_____ X

If yes, please describe your plans:

24. Key Investigator Qualifications. Briefly describe the education, research interests and experience and professional commitments of the Principal Investigator and all other key investigators. In place of narrative you may insert the NIH biosketch form here; however, please limit each biosketch to 1-2 pages.

George J. Pappas

EDUCATION

Ph.D., EECS, University of California at Berkeley, Berkeley, CA, December 1998.

M.S., CSE, Rensselaer Polytechnic Institute, Troy, NY, December 1992.

B.S. , CSE,(Magna Cum Laude) Rensselaer Polytechnic Institute, Troy, NY, December 1991.

ACADEMIC EMPLOYMENT

Deputy Dean for Research, School of Engineering and Applied Sciences, *University of Pennsylvania*, Philadelphia, PA. January 2008 to June 2012.

Director, General Robotics Automation Sensing Perception (GRASP) Lab, *University of Pennsylvania*, Philadelphia, PA. August 2005 to January 2008.

Joseph Moore Professor, *Departments of Electrical and Systems Engineering and Computer and Information Sciences*, *University of Pennsylvania*, Philadelphia, PA. July 2007 onwards.

Associate Professor, *Departments of Electrical and Systems Engineering and Computer and Information Sciences*, *University of Pennsylvania*, Philadelphia, PA. July 2004 to July 2007.

Assistant Professor, Graduate Group Chair, *Departments of Electrical and Systems Engineering and Computer and Information Sciences*, *University of Pennsylvania*, Philadelphia, PA. March 2000 to July 2004.

HONORS AND AWARDS

Antonio Ruberti Young Researcher Prize, IEEE Control Systems Society, 2010.

George S. Axelby Outstanding Paper Award, IEEE Control Systems Society, 2009.

IEEE Fellow, Class of 2009.

Finalist, Best Paper Award, IEEE/RSJ Intelligent Robots and Systems 2007

Finalist, Best Student Paper Award, IEEE Robotics and Automation 2007

N.A.E.-A. von Humboldt German-American Frontiers of Engineering Program, 2007

Presidential Early Career Award for Scientists and Engineers (PECASE), 2002, NSF CAREER Award, 2002

Finalist, Best Student Paper Award, IEEE Conference on Decision and Control 1998, 2001, 2004, 2006

Finalist, Best Student Paper Award, American Control Conference 2001, 2004

Eli Jury Award for Excellence in Systems Research, University of California at Berkeley, 1999

TEACHING

ESE 680, Optimal Control Theory, Fall 2011

ESE 680, Green Buildings: Optimization and Adaptation, Spring 2011

ESE 680, Special Topics in Systems Biology, Spring 2007

ESE 301, Introduction to Probability, Spring 2006, Spring 2007, Fall 2007

ESE 325, Structure and Interpretation of Signals and Systems, Spring 2003, Spring 2004

ESE 500, Linear System Theory, University of Pennsylvania, Fall 2001, 2002.

ESE 601, Hybrid Systems, University of Pennsylvania, Fall 2000, Fall 2003, Spring 2006.

EECS 222, Nonlinear Systems : Analysis, Stability, and Control, University of California at Berkeley, Spring 1999.

CURRENT GROUP

Nikolay Atanasov, Ph.D. ESE, Chinwendu Enyioha, Ph.D. ESE, Konstantinos Gatsis, Ph.D. ESE, Fragkiskos Koufogiannis, Ph.D. ESE, Jerome Le Ny, Postdoctoral Researcher, ESE, Ioannis Mantzouranos, Ph.D. CIS, Fei Miao, Ph.D. ESE, Truong Nghiem, Ph.D. ESE,

FORMER GROUP MEMBERS

Mohamed Babaali (Mathworks), Thao Dang (CNRS), Antoine Girard (Universit'e Joseph Fourier), Agung Julius (Rensselaer), George Fainekos (Arizona State), Hadas Kress Gazit (Cornell), P.K. Mishra (General Motors R&D), T. John Koo (Shenzen), Shreyas Sundharam (Waterloo), Selman Sakar (MIT/ETH), Paulo Tabuada (U.C.L.A.), Herbert Tanner (Delaware), Hakan Yazarel (Toyota Technical Center, Berkeley), Michael Zavlanos (Stevens Institute).

SELECTED SYNERGISTIC ACTIVITIES

Steering Committee Chair, *Cyber-Physical Systems (CPS) Week*, St. Louis, MI, April 2008-April 2011.

Academic Executive Board, Cyberphysical Systems (CPS), National Science Foundation, August 2010-present.

Co-organizer, NSF-IST-TEKES workshop on *Long Term Challenges in High Confidence Composable Embedded Systems*, Helsinki, Finland, June 2006.

Participant, NSF-ISTWorkshop on *Transatlantic Research Agenda on Future Challenges in Embedded Systems Design*, Paris, France, July 2005.

Co-organizer, National Coordinating Office (NCO) - NSF Workshop on *High Confidence Medical Device Software and Safety*, Philadelphia, PA, June 2005.

International Advisory Board Member, Embedded Systems Institute, Eindhoven, Netherlands, 2007-present.

Steering Committee Chair, *Hybrid Systems : Computation and Control*, 2006-present.

FIVE RELATED PUBLICATIONS

1. Network integrity in mobile robotic networks. Michael Zavlanos, Alejandro Ribeiro, and George J. Pappas. *IEEE Transactions on Automatic Control*, Accepted.
2. Adaptive Deployment of Mobile Robotic Networks. J. Le Ny and G. J. Pappas, *IEEE Transactions on AutomaticControl*, Submitted.
3. Graph theoretic connectivity control of mobile robot networks. Michael Zavlanos, Magnus Egerstedt, and George J. Pappas. *Proceedings of the IEEE*. 99(9):1525-1540, September 2011
4. Stochastic source seeking in complex environments. Nikolay Atanasov, Jerome Le Ny, Nathan Michael, and George J. Pappas. In *Proceedings of the IEEE Conference on Robotics and Automation*, Minnesota, MN. May 2012.
5. Courteous cars: decentralized multi-agent traffic coordination Hadas Kress-Gazit, David C. Conner, Howie Choset, Alfred A. Rizzi, and George J. Pappas *IEEE Robotics and Automation Magazine*, 15(1):30-38, March 2008.

FIVE OTHER PUBLICATIONS

1. The wireless control network: a new approach for control over networks. Miroslav Pajic, Shreyas Sundaram, George J. Pappas, Rahul Mangharam. *IEEE Transactions on Automatic Control*. 56(10):2305-2318, October 2011.
2. Compositional modeling and analysis of multi-hop control networks. Rajeev Alur, Alessandro D’Innocenzo, Karl H. Johansson, George J. Pappas, and Gera Weiss. *IEEE Transactions on Automatic Control*. 56(10):2345-2357, October 2011.
3. Approximation metrics for discrete and continuous systems. Antoine Girard and George J. Pappas. *IEEE Transactions on Automatic Control*, 52(5):782-798, May 2007. (George Axelby Award, 2009)
4. Temporal Logic Based Reactive Mission and Motion Planning. Hadas Kress-Gazit, Georgios Fainekos, and George J. Pappas. *IEEE Transactions on Robotics*. 25(6):1370-1381, December 2009.