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National Nanotechnology Initiative
Federal Resources for the Development of
Nanosensors

Lisa Friedersdorf
National Nanotechnology Coordination Office

Thursday June 25, 2015
Nanotechnology Signature Initiative Webinar Series

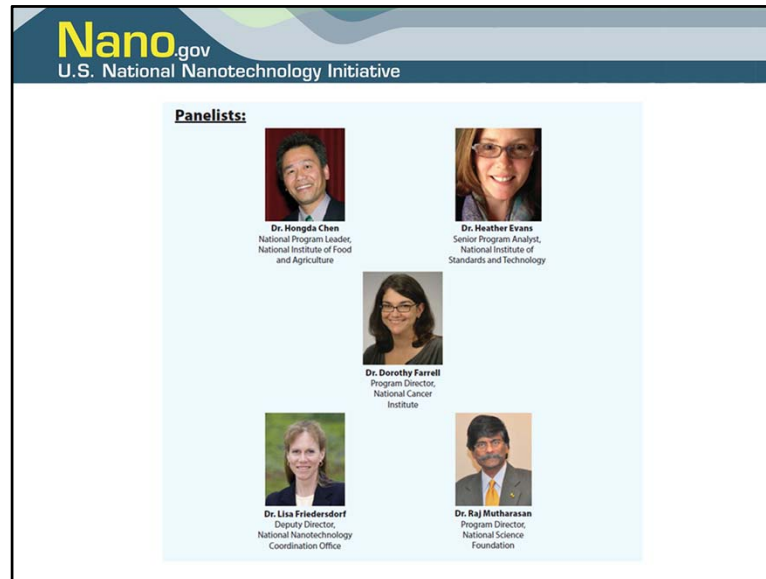
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>> **Dr. Lisa Friedersdorf:** Good morning and welcome to the National Nanotechnology Initiative Federal Resources for the Development of Nanosensors webinar. It is my pleasure to welcome you, and I would like to give you a brief summary of what we hope to accomplish today.

Welcome

- Introduction to Federal panelists
- Announcement regarding Grand Challenges
- Overview of Nanotechnology Signature Initiatives (NSIs)
- Brief history of the *Nanotechnology for Sensors and Sensors for Nanotechnology: Improving and Protecting Health, Safety, and the Environment* Nanotechnology Signature Initiative (Sensors NSI)
- Sensors NSI Web Portal Demonstration
- Q&A with Federal Panel

>> **Dr. Lisa Friedersdorf:** Shortly, each of the federal panelists will introduce themselves. We will make a very brief announcement regarding grand challenges, and then provide an overview of the Sensors Nanotechnology Signature Initiative (Sensors NSI). We will then have a demonstration of the new Sensors NSI web portal. Finally, we will use the remaining time with a Federal panel answering questions from you.



>> **Dr. Lisa Friedersdorf:** My name is Lisa Friedersdorf. I am the Deputy Director at the National Nanotechnology Coordination Office, and I will be serving as moderator today. Let's go around the table to introduce the remaining panelists.

>> **Dr. Hongda Chen:** This is Hongda Chen from the National Institute of Food and Agriculture of USDA.

>> **Dr. Raj Mutharasan:** I am Raj Mutharasan from the Engineering Directorate at the National Science Foundation. I manage a program on biosensors.

>> **Dr. Heather Evans:** I am Heather Evans. I work at the National Institute of Standards and Technology.

>> **Dr. Dorothy Farrell:** My name is Dorothy Farrell. I work at the National Cancer Institute. We have interests in the application of sensors in diagnostic devices as well as for environmental and health implications, which are becoming more important as nanomaterials enter the industrial landscape.

>> **Dr. Lisa Friedersdorf:** Now you have heard our voices and will know who is responding as we go forward.

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Nanotechnology-Inspired Grand Challenges for the Next Decade

Office of Science and Technology Policy

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A Call for Nanotechnology-Inspired Grand Challenges

Posted by Lloyd Whitman and Tom Kall on June 17, 2015 at 11:58 AM EDT

Today, June 17, the Office of Science and Technology Policy issued a Request for Information (RFI) seeking suggestions for Nanotechnology-Inspired Grand Challenges for the Next Decade. A Grand Challenge is an ambitious but achievable goal that requires advances in science and technology to achieve, and that has the potential to capture the public's imagination.

Under the National Nanotechnology Initiative (NNI), scientists, engineers, and educators are building a future in which the ability to understand and control matter at the nanoscale leads to a revolution in technology and industry. The collective effort of this community to achieve the vision of the NNI has greatly accelerated the discovery, development, and deployment of nanotechnology to address broad national needs.

Examples of sensor-relevant grand challenges in the RFI:

- *Create devices no bigger than a grain of rice that can sense, compute, and communicate without wires or maintenance for 10 years, enabling an "internet of things" revolution*
- *Determine the environmental, health, and safety characteristics of a nanomaterial in a month*

Link to the RFI: <https://federalregister.gov/a/2015-14914> **Deadline: July 16, 2015**

>> **Dr. Lisa Friedersdorf:** I would like to call your attention to an announcement that was recently made from the White House Office of Science and Technology Policy. This is a Request for Information, more information is available from the Federal Register or the front page of nano.gov. This Request for Information is seeking input on Nanotechnology-Inspired Grand Challenges, and for this particular community, there are a number of sensors applications that may be of interest. Two examples called out in the Request for Information are listed here. I encourage you to go to nano.gov for more information and, of course, contact us if you have any questions.

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Nanotechnology Signature Initiatives

The Nanotechnology Signature Initiatives (NSIs) are designed to *accelerate innovation* in areas of national priority through enhanced interagency coordination and collaboration:

- *Address R&D gaps* within areas of critical national need
 - Identify research *thrust areas*
 - Select *key research targets* associated with near-and long-term expected outcomes
- *Leverage* skills, resources, and capabilities among multiple NNI agencies to maximize scientific and technological progress
- Provide a forum for communication and *ongoing assessment* of direction and progress
- *Catalyze* communities of practice and public private partnerships to accelerate commercialization

>> **Dr. Lisa Friedersdorf:** Now, for a brief overview of the Nanotechnology Signature Initiatives. The Signature Initiatives are designed to be collaborative and coordinated activities among the Federal agencies that make up the NNI. The Signature Initiatives are intended to accelerate innovation in areas of national priority and focus on areas that can benefit from enhanced interagency activities. The NSIs leverage resources and capabilities of the NNI agencies to maximize progress and provide a forum for ongoing communications. The NSIs are not intended to be a purely Federal activity, but to catalyze communities of interest that extend into academia and industry.



>> **Dr. Lisa Friedersdorf:** There are currently five Signature Initiatives. Three were announced in July of 2010. These are in Solar Energy Collection and Conversion, Sustainable Nanomanufacturing, and Nanoelectronics. In May of 2012, the Signature Initiative that we referred to as the Nanotechnology Knowledge Infrastructure or the NKI, which is in part an informatics activity, was announced. And in July of 2012, almost three years ago, the Sensors Signature Initiative was launched.

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Nanotechnology for Sensors and Sensors for Nanotechnology: Improving and Protecting Health, Safety, and the Environment

Agencies involved: CPSC, DOD/DTRA, EPA, FDA, NASA, NIH, NIOSH, NIST, NSF, USDA/NIFA

Goals: Support research on nanomaterial properties and development of supporting technologies that enable next-generation sensing of biological, chemical, and nanoscale materials.

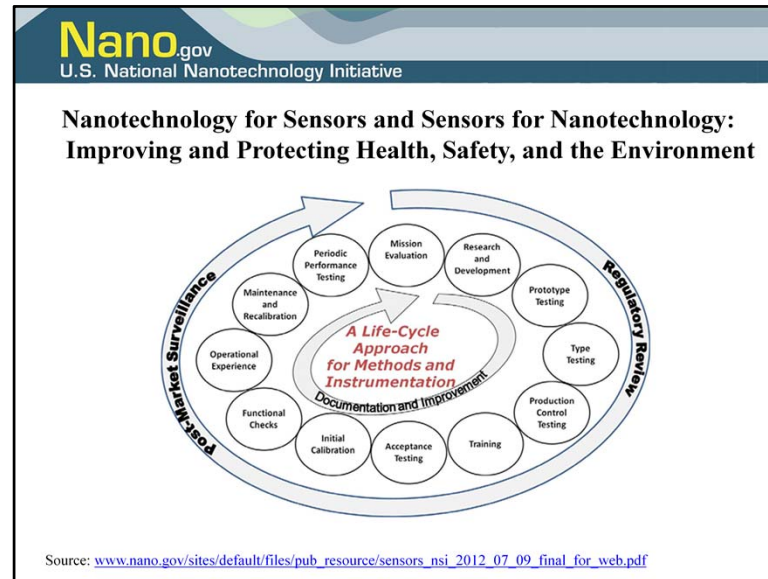
Thrust Areas:

- Using nanotechnology and nanoscale materials to build more sensitive, specific, and adaptable sensors in order to overcome the technical barriers associated with conventional sensors
- Developing new sensors to detect engineered nanomaterials across their life cycles, in order to assess the potential impact on health, safety, and the environment

Multiplexed Sensor System

optical electrochemical magnetic mechanical
Nanotechnology-enabled Transducers

>> **Dr. Lisa Friedersdorf:** On this slide you can see the many Federal agencies that are involved in the Sensors Signature Initiative. Several of them represented here today. The Sensors NSI has two thrust areas: one is focused on using nanotechnology to enable sensors, and the second thrust area is sensors to detect nanomaterials in complex media.



>> **Dr. Lisa Friedersdorf:** The Sensors NSI uses a lifecycle approach which is detailed further in the white paper document and on Nano.gov. There are agency activities in support of this initiative that address each stage of the lifecycle.

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Engaging with Stakeholders

- Town hall meetings
- 2013 Request for Information
- Sensor Fabrication, Integration, and Commercialization Workshop
- www.nano.gov/SensorsNSIPortal



The image displays three screenshots related to the Sensors NSI initiative. On the left, the 'TechConnect WORLD Nano tech' logo is shown. In the center, a screenshot of the Federal Register notice titled 'Request for Information: NNI Nanotechnology for Sensors and Sensors for Nanotechnology Signature Initiative' is visible. On the right, a screenshot of the 'NNI Sensor Fabrication, Integration, and Commercialization Workshop' proceedings is shown, dated September 11-12, 2014, featuring three colorful abstract graphics.

>> **Dr. Lisa Friedersdorf:** Over the past three years, there have been a number of activities to engage the public in addition to the interagency Federal efforts in support of the goals of the Sensors NSI. For example, there have been technical sessions coordinated in national conferences and town hall meetings; in 2013 the group released a Request for Information, feedback from which informed the organization of a workshop; and finally the portal that we will be demonstrating today.

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In 2013, the NNI issued a Request for Information (RFI) on Nanotechnology for Sensors and Sensors for Nanotechnology

FEDERAL REGISTER
The Daily Journal of the United States Government

Request for Information: NNI Nanotechnology for Sensors and Sensors for Nanotechnology Signature Initiative

A Notice by the Science and Technology Policy Office and the National Nanotechnology Coordination Office on 10/01/2013

ACTION Notice Of Request For Information.

SUMMARY The purpose of this Request for Information (RFI) is to enhance the value of the National Nanotechnology Initiative (NNI) and of the Nanotechnology Signature Initiative (NSI) entitled Nanotechnology for Sensors and Sensors for Nanotechnology in particular, by reaching out to the nanotechnology stakeholder community for input regarding specific needs for the accelerated development and commercialization of nanosensors. This RFI is intended to inform planning for a public workshop organized under the auspices of the sensors NSI.

Link: <https://federalregister.gov/a/2013-23916>

The RFI focused on these five themes:

- Standards
- Testing
- Manufacturing
- Commercialization
- Regulation

>> **Dr. Lisa Friedersdorf:** To give you a little more information about the request for information, which can be found in the Federal Register and also from links provided on nano.gov, the Request for Information was seeking feedback in five theme areas: standards, testing, manufacturing, commercialization, and regulation.

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Examples of Questions in the RFI for Nanotechnology for Sensors and Sensors for Nanotechnology NSI

- Regulation:** How can regulatory requirements be best shared with the sensors community?
- Commercialization:** What are the primary contributing factors to the existence of a “valley of death” for sensor development and commercialization?
- Manufacturing:** What are the largest technical challenges and workforce issues in manufacturing facing sensor development?
- Testing:** What capabilities would be highest priority if new sensor testing facilities were to be developed?
- Standards:** What standards need to be developed (for performance or manufacturing) to meet industry/consumer expectations for emerging sensor technologies?

>> **Dr. Lisa Friedersdorf:** To give you some examples of the types of questions that were included: How can regulatory requirements be best shared with the sensors community? What capabilities would be of highest priority for new sensor testing—if new sensor testing facilities were to be developed? And there are a number of other questions that are listed under each one of the theme areas.

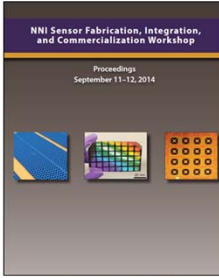
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Sensor Fabrication, Integration, and Commercialization Workshop
September 10–11, 2014.

This workshop focused on identifying **key challenges** faced by sensor developers and on determining the **critical needs** of the community, especially with respect to necessary **standards, testing facilities, and advances in manufacturing.**

Key workshop outcomes:

- Critical need to access **test conditions** beyond standard laboratory environments
 - Realistic test beds are essential for the relevant and reliable transition of prototype sensors from research to commercial use.
- The need for sensor developer access to **fabrication facilities** beyond the prototype stage
 - Especially prior to large-scale production, to demonstrate performance characteristics, reproducibility, and other measures required for adoption.
- Support for **enhanced communication**
 - Including a desire to share best practices and resources
 - www.nano.gov/SensorsNSIPortal




www.nano.gov/SensorsReport2015

>> **Dr. Lisa Friedersdorf:** The feedback that we received from the public in response to the Request for Information led to the development of a workshop. The workshop began with a review of the lifecycle approach and a summary of results from the RFI. The plenary session included case studies of commercialization from a large company and a panel of representatives from small businesses, and presentations from FDA and EPA regarding navigating the regulatory processes. Breakout sessions focused on key challenges and next steps for sensor technologies in the areas of standards, development and testing, manufacturing, and commercialization. Key outcomes from this workshop included a critical need to access test conditions beyond what is available in a laboratory setting, the need for sensor development fabrication facilities, and support for enhanced communication. There was a desire from the community for sharing the best practices and resources, and this led to the development of the sensors web portal, which we will be demonstrating shortly. So that provides a brief summary of some of the activities that have been in support of the Sensors Signature Initiative. Is there anyone in the room who would like to add anything to this summary? [Pause] Hearing none, we will move on to the demonstration of the web portal.

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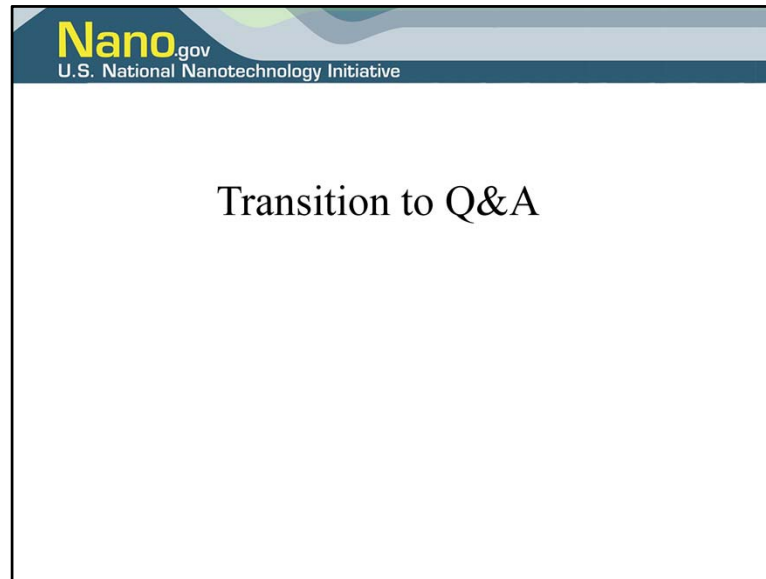
Web Portal Demonstration



The screenshot displays the Nano.gov website. The header features the Nano.gov logo and the text 'U.S. National Nanotechnology Initiative'. Below the header, the main content area is titled 'NSI: Nanotechnology for Sensors and Sensors for Nanotechnology -- Improving and Protecting Health, Safety, and the Environment'. The page includes sections for 'Overview of NSI Activities' and 'Related Resources'. The 'Overview of NSI Activities' section contains text about nanotechnology's role in addressing global challenges and improving quality of life. The 'Related Resources' section lists links for 'Click here for the Nanotechnology White Paper', 'Click here for the Nanotechnology White Paper', and 'Click here for the Nanotechnology White Paper'. The page also features a search bar and navigation links.

Full demonstration is available at: <https://nnco.adobeconnect.com/p6j297ubj6f/>

During the live webinar, Dr. Dorothy Farrell demonstrated the web portal. NNCO Staff Scientist, Dr. Stacey Standridge, used the transcript from the live demonstration to develop the tutorial found here: <https://nnco.adobeconnect.com/p6j297ubj6f/>



>> **Dr. Lisa Friedersdorf:** Thank you, Dorothy! I would like to add that this portal is really intended for public use, and we built it in response to stakeholder needs. The Signature Initiative is not just a Federal activity. It is intended to develop a community of interest for the advancement of sensor technologies. So as you have an opportunity to look through this website, if there is useful information or things that you wish were better, we would love your feedback by contacting NNCO. We really want this to be a useful, living tool. We expect more information to be added as the technology develops, and we will continue to update this website so that it will be useful to the community. We will now transition now into the question and answer portion of the webinar. If you have a question, please send them to NNCO. The alias in the web announcement will come directly to us if you have questions that you would like to submit.

Can you describe examples of educational and training tools that are included in the sensors NSI web portal?

>> **Dr. Lisa Friedersdorf:** We will start with some questions that we already have, and the first question is: *Can you describe examples of educational and training tools that are included in the sensors NSI web portal?* And we will turn to Raj.

>> **Dr. Raj Mutharasan:** Yes, there are several ways of getting this information, particularly educational tools. I think it was highlighted in the earlier presentation, but nanoHUB.org is an organization that is funded by National Science Foundation. It is a large portal to which a great number of educational materials have been integrated into it. It is a multi-university portal if you will, and, for example, if you wanted to take a course in nanoelectronics, you could sit in through 30 hours of lecture. But you also will be able to participate in the experiments, and you will also be able to draw in, for example, molecular dynamics on surfaces of nanoparticles. So it is a very, very rich resource for education. If you want training, this is a little bit special. If you make those requests through the portal, there might be some universities that will bring forth possible training tools, but I would urge you to get through the educational part and then look for specialized training programs that might be available. The NSF does fund summer programs that are permanently targeted at undergraduate students who go to different specialized laboratories on specialized topics in nanotechnology and get training over a period of about ten weeks. That funding occurs through both the Science Directorate as well as the Engineering Directorate, but I am not sure whether one of those might be available for practicing engineers. You can get in touch with one of those coordinators to see whether they might allow you to sit in on one of those courses along with the undergraduate students. Other resources that are available in the open space include for example coursera.org, a website that has complete courses and courses are taught from all over the world, all the way from Europe, China, India, and U.S. of course. Most of them are in English, and you can take an entire course on nanotechnology. In fact, there is one that just completed being taught from Israel on nanosensors, so there is a whole resource of educational materials that is available in the open web source.

>> **Dr. Dorothy Farrell:** I also want to add to these resources the Nanotechnology Characterization Laboratory (NCL), which is supported by NCI. The NCL evaluates nanomaterials intended for use in clinical cancer applications and maintains a webpage with protocols for characterizing nanomaterials, *in vitro* and *in vivo*. The webpage also includes videos, including on how to properly do light scattering, for example, which is typically not actually done well. I believe if you are in a cancer-relevant space, I believe they will occasionally actually allow visitation to learn to use a particular piece of equipment. There is a link to NCL on the web portal. It is a valuable source of information for best practices in characterizing nanomaterial properties.

>> **Dr. Hongda Chen:** Workforce training is also a critical part of the National Nanotechnology Initiative. Raj (of NSF) mentioned relevant programs in this area, and I would like to add that USDA/NIFA supports curriculum development as well as graduate student and post-doctoral opportunities. Those can be explored to further develop educational tools for training future workforce in the nanotechnology area.

>> **Dr. Lisa Friedersdorf:** I would also point to the nano.gov website. There are a number of educational programs listed there. Many universities offer courses and/or degree programs at the technician, undergraduate, and advanced degree levels. NSF sponsored a workshop in December of last year that focused on Nanoscale Science and Engineering Education in a variety of levels, all the way from K-12 to university training and informal education. This report is undergoing review and will be released soon on nano.gov. It will highlight a number of resources that are currently available.

Is there any direct support to initiate nanosensor development for small businesses other than SBIRs?

>> **Dr. Lisa Friedersdorf:** I would like to pose a question that just came in to the panel: *Is there any direct support to initiate nanosensor development for small businesses other than SBIRs?*

>> **Dr. Dorothy Farrell:** There are several solicitations on the Sensors NSI web portal, including, for example, the Innovative Molecular Analysis Technologies program. Most prospective grantees don't realize that most NIH support is open to small businesses. The announcements typically include information on who is eligible to apply. A small business that is developing innovative nanosensors is more than welcome to apply to the IMAT program for example, which will support early stage feasibility studies (what we call the R21: \$400,000 over three years, with no more than \$200,000 in any one year) and for more advanced development stages (R33: \$300,000 a year for no more than three years).

>> **Dr. Heather Evans:** NIST has currently an open announcement for funding opportunity that is available on a rolling basis. Our Measurement Science and Engineering (MSE) Research Grant Programs is posted currently on grants.gov. It is also in the Sensors NSI web portal, currently under the Partnering page. It is one of the links you can get to if you click on "Collaborating with NIST." Currently you could apply for a research grant to partner with the material measurement laboratory, which is very interested in the types of issues that would be relevant for sensor development. SBIR remains probably one of the most well-known resources for small businesses and they recently have updated their website. So you might find it even more useful.

>> **Dr. Raj Mutharasan:** NSF has also a number of different programs within the Engineering Directorate. The Industry and University Cooperative Research Program grant opportunity can be driven primarily by universities, but it could be initiated by industry. So if you find a partner in a university, you could collaboratively come up with two programs that are richly supported, by the way. The Grant Opportunities for Academic Liaison with Industry (GOALI) also promotes university-industry partnerships by making project funds or fellowships available to support an eclectic mix of industry-university linkages. It is not commonly found, so we like to support research that can be transitioned into practical devices. So you may want to look into those opportunities. They are not extremely budget limited and have fairly liberal level of funding to be able to do early research in device.

>> **Dr. Lisa Friedersdorf:** Thank you. I would like to remind the viewers of this webinar and listeners, as it may be, that we have select agency representatives that were available to take part in the webinar today, but there are a number of agencies that are involved in the Signature Initiative. More information is provided on that web portal that Dorothy demoed earlier, and the program pages would have more detail about opportunities that exist in agencies that are not represented today.

What consensus standards are available or under development for sensor technologies? How have these standards helped in measuring sensor performance?

>> **Dr. Lisa Friedersdorf:** I would like to move on to the next question, which is: *What consensus standards are available or under development for sensor technologies? How have these standards helped in measuring sensor performance?* I will turn to Heather from NIST to start.

>> **Dr. Heather Evans:** Dorothy did a great job talking through the sensors web portal. There are actually two pages that describe standards resources, and there you will find groups that develop consensus documentary standards, reference materials, and the standard reference materials that can be used for calibrating and benchmarking your sensor performance. There are many reference materials that NIST has for sale currently; gold nanoparticles being one of the ones we saw a picture of in the demonstration. So those are really important to better characterize and understand your performance. On the other hand, documentary standards have a very important role to play as well. As Dorothy mentioned, there are a few well-known groups, IEC being one, that puts out these standards that are developed internationally. So you have opportunities to engage with ASTM International, IEC, and ISO. An example there would be something like the IEC61588; it is a standard important for sensor and measurement systems that help define time synchronization, which is a central component of many platforms that you might be working on. That's an example, but you can find more detail at the portal.

>> **Dr. Dorothy Farrell:** There was a question about the NIH program I have referenced. It is called the Innovative Molecular Analysis Technologies program or IMAT. There are two types of grants: one is called R21 where the work is still preliminary. It is about \$400,000 over three years. There is also the R33. This is when you have your device and the early feasibility data, and you need to do a little bit of validation, and basically get the sort of data that might help you get more interest from a larger company partner or from somebody who might be interested in licensing it. I believe that is more on the order of \$300,000 a year. One thing I forgot to mention and that is related to standards is the Cancer Relevant Biospecimen Science program. It might be of interest as well, particularly if you are interested in standards, because it supports innovative technologies that address issues related to the pre-analytical variables that affect biospecimen quality. If you are interested in standards from development point of view, the Biospecimen Science program is linked to on the web portal. Again, as for IMAT, I don't believe you have to be a university to apply. Small businesses can apply to our funding.

>> **Dr. Raj Mutharasan:** By the way, this is also true for NSF. Businesses can apply to our regular grants. As long as you meet the intellectual merit and broader impact criteria, it will be eligible for funding.

>> **Dr. Hongda Chen:** This is also true for the flagship competitive grant program of USDA/NIFA called the Agriculture Food And Research Initiative. Small businesses are also eligible for the grants, and the scope of research could be rendered from basic to applied. The door is wide open.

What lessons have been learned that would be useful to pass on to those who contemplate developing and commercializing sensors?

>> **Dr. Lisa Friedersdorf:** Thank you. I would like to move on to the next question: *What lessons have been learned that would be useful to pass on to those who contemplate developing and commercializing sensors?* And we will start with Hongda.

>> **Dr. Hongda Chen:** This is a great question. I think many people are interested in this topic. I will refer you to the chapter 5 of a workshop report, which will provide you much more detail, and we heard a lot of input from workshop participants on this topic. Very briefly, I will capture major points of great significance: first is planning, second is communication, and third is leveraging resources. In terms of proactive planning from proof-of-concept to commercialization, you need to chart your course throughout the entire process. You need to have an assessment to match intellectual concepts to product needs; you need to have a market analysis to create tangible value to consumers and end users. How do you engage regulatory approval process and requirement – engage regulatory agencies from get-go? And how do you ensure the compliance with established standards? What about manufacturing? How do you identify access to the fabrication facility? In terms of enhanced communication for engagement, you need to think about how do you become potential partners between business and potential customers? How would you share information and best practices to transverse across the “Valley of Death?” How do you consider research involved in manufacturing to facilitate commercialization? In terms of leveraging resources, the NNI agencies provide research and development funding – FY14 Actual NSI sensors investment is \$58M. Public and private partnership can also help build critical facilities such as test beds and pilot scale foundries. The NSI sensor portal is an important tool. Dorothy has demonstrated the Sensors NSI web portal and showed a breadth of resources, including opportunities available for facilities, guidance documents, and published standards. Now, your involvement is needed in exploiting these resources to successfully advance your sensors.

>> **Dr. Lisa Friedersdorf:** Thank you very much. I would like to point again to the workshop report, which we did have several case studies where small businesses and large businesses shared their experiences in commercializing sensor platforms, and we hope this is something that will be helpful.

How can sensor developers engage with Federal agencies to gain access to characterization tools or other resources?

>> **Dr. Lisa Friedersdorf:** I also would like to follow up on another comment that Hongda just made and move onto the next question: *How can sensor developers engage with Federal agencies to gain access to characterization tools or other resources?*

>> **Dr. Heather Evans:** We discussed this point during the overview of the web portal. If you look on the “Testing and Commercialization” support tab you will find some information, as Dorothy indicated, which we will be updating constantly with new resources. One program I am of course familiar with is the Center for Nanoscale Science and Technology, a user facility on the NIST campus in Maryland that provides rapid access to state-of-the-art commercial tools as well as technical staff to work with you and help you improve the device you are building and also better characterize the performance. There might be other opportunities to work with agencies, such as the Army Research Laboratory, with the recently promoted “Open Campus Initiative,” which provides a new mode of collaboration.

>> **Dr. Dorothy Farrell:** I wanted to throw out the NCL as great resource. I think one of the most important things is identifying a contact to help you, which I know can be difficult. In previous discussions, we have pointed out that NIOSH and EPA can help test a sensor but this is not part of a formal program. For example, EPA has air monitoring stations, which we link to on the portal, and when you locate the contact person for that they can let you know if they have an ability to take a sensor on board for testing. NIOSH has a Center for Direct Reading and Sensor Technology and is looking to collaborate. If you are interested in sensing nanomaterials, they have the ability to place sensors in occupational settings.

>> **Dr. Lisa Friedersdorf:** Thank you, Dorothy, and I also would like to point out to the NNI facilities webpage on nano.gov, which includes the NSF National Nanomanufacturing Network, the DOE National Laboratories, and the Department of Defense laboratories among many others. There are a number of resources that stakeholders can tap into, and there is information available on nano.gov. I agree that some of the challenges is finding an appropriate contact, and that is a role that NNCO can play as well, if there are questions or you need help contacting a person.

Can you elaborate on how the NNI perceives citizen science and contribution to nanotechnology innovation and regulation through the Sensor NSI?

>> **Dr. Lisa Friedersdorf:** I would like to move into another question that came in, and this is: *Can you elaborate on how the NNI perceives citizen science and contribution to nanotechnology innovation and regulation through the Sensor NSI?*

>> **Dr. Dorothy Farrell:** I want to preface by saying I am giving what I think is my opinion on this question. I don't know that the NNI itself has a set perception, so I don't want to say this is policy, but I think one thing we recognize in discussing the initiative is that citizen science is going to play an important role in sensing, because people talk about the Internet of things. That is basically everybody walking around with a lot of sensors and making sense of that, and using that data is going to require citizen science and require people donating their data, participating in data collection. In fact, it is closed now but about a year ago, EPA, for example, had an open call that was really grants to enable citizen science distributed air monitoring. So I do think this is something agencies are coming online for. I don't know that it is 100% ready to go. We perceive it as something that will be necessary and that already is beginning to happen, and I know there is interest in this in NIH as well. It goes back to the concept of nanoparticle databases: if everybody could share their data, we would really know a lot more.

Is there a bias/focus towards a particular nanomaterial? For example, in the EU, graphene is a major focus at the moment.

>> **Dr. Lisa Friedersdorf:** We have had another question that just came in: *Is there a bias/focus towards a particular nanomaterial? For example, in the EU, graphene is a major focus at the moment?*

>> **Dr. Raj Mutharasan:** I think from the NSF's perspective, it is the ideas that matter. We don't want to say which is better than which. We let the community of scientists decide that. So we would be very interested in any new material that will solve a problem in the context of sensing.

>> **Dr. Heather Evans:** At NIST we actually have a number of programs on materials, and we have a lot expertise in graphene. We pursue several materials, including nanowires for applications in sensing. When we look at our nanoEHS program, we try to target nanomaterials that we think are going to be in highest manufacture, which is actually not going to be something like graphene at the moment. We looked at titanium dioxide, which is a little bit different. I would say in the U.S. we have a slightly different funding structure than they have in the EU, so we don't really see a single material that is the core focus right now.

>> **Dr. Lisa Friedersdorf:** I just want to emphasize one of the things that Raj said: it is the application that is of interest or the performance that is of interest and how you get to solve that problem that is more important than what you use. So even in the case where there are solicitations or needs by agencies that don't specify nanomaterials, if nanomaterials can provide the solution, they could be applicable. It is not necessarily decided ahead of time what the material or path forward that solution might be.

Is there a searchable database that includes information on funded sensor technologies?

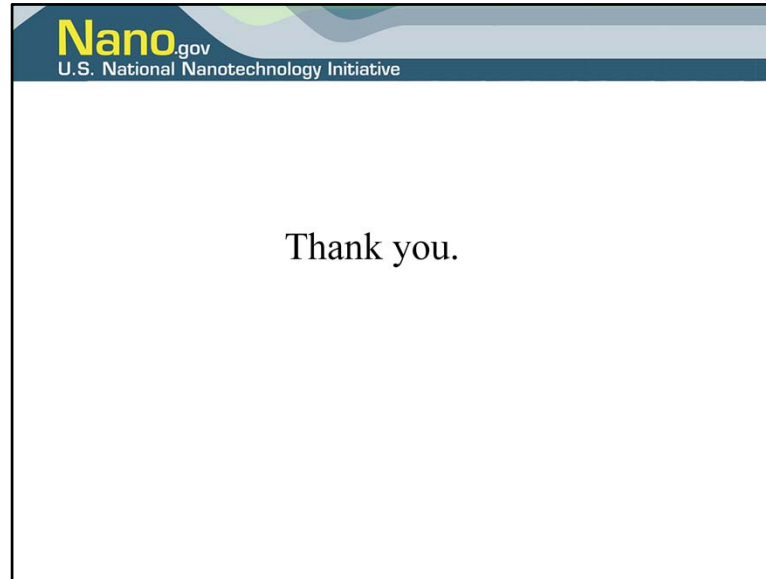
>> **Dr. Lisa Friedersdorf:** Let's move to the next question: *Is there a searchable database that includes information on funded sensor technologies?*

>> **Dr. Dorothy Farrell:** The answer to this is yes and no. There are several databases of technology developed by scientists within the federal government and available for licensing: Tech Link and the Federal Laboratory Consortium are good examples. It is much easier to search for technology that was supported directly by the Federal government. For technology development supported by federal funds but done outside the government, you would have to infer the existence, I think. SBIR has a pretty good search tool of awards that have been made, by keyword, and these are across agencies. So what this would let you do is put in the type of sensor you are interested in, and that would at least narrow down companies that have that interest because they were funded to do research on that sensor. It is something you have to infer. This is also true for the NSF.gov award search. NIH RePORTER is the website where you can search all funding, which is actually public knowledge. You can do key word searches to discover the people who are interested in a topic. They are not always the easiest databases, but RePORTER, for instance, has an unbelievable amount of data. You have to be patient, and you don't want to search for "sensors." You want a specific search. Actually I believe NIFA has also a database, and I think the size of the agency it might guide how you do your search. NIH is enormous. We have a lot of grants, so you really need to narrow down your search. We don't have an exact listing of the technologies, but we do have all of the funding available. As a side note, it is also worthwhile if you are going to apply for funding to use RePORTER to investigate what has been funded already.

>> **Dr. Lisa Friedersdorf:** We are winding down with a few minutes left here, and I think that we have identified a number of resources that are available on the web portal. We pointed you to the workshop report that I think is very valuable. Going back to the last question and talking about funded technologies and actual matchmaking, I think a number of the resources that were discussed today can help stakeholders find activities funded through solicitations that are requesting certain technologies. Also last week, we attended the 2015 TechConnect meeting where there is a conscious attempt to connect early stage developers with later stage. There are other similar opportunities at professional society meetings and SBIR national meetings that will help people find each other.

>> **Dr. Dorothy Farrell:** I want to jump in with one more thing: if you are an early stage sensor developer and facing challenges in commercializing your platform, TechConnect hold sessions where late stage developers will describe their technology needs. There is value to going there and talking to people about what they think they could use your sensor for. There is also value in doing this early because identifying the right application for your sensor is the one thing that will get you to market.

>> **Dr. Heather Evans:** One last opportunity for funding that might be of interest to the audience is looking on challenge.gov. A number of agencies (Dorothy has alluded to that) have solicitations, but right now there are a lot of opportunities and contests held on challenge.gov where they are searching for a best solution. It does not necessarily mean that they are looking for a nanosensor, but there may be an opportunity that could fit such criteria.



>> **Dr. Lisa Friedersdorf:** We are in our closing minute here. We first would like to thank you for attending this webinar and having the interest to learn more about the Sensors Signature Initiative and the Sensors NSI web portal that was demonstrated today. I would like to remind you about my initial announcement regarding the *Nanotechnology-Inspired Grand Challenges* and encourage you to look at the RFI to provide a response. As a group that is very interested in seeing the advancement of sensor development, we really welcome your feedback on this portal and on the information that we have provided and welcome your suggestions on how we can provide the information to you in the most useful manner.

With that, I thank you very much for participating and to all the Federal panelists who took the time today to be a part of this. Thank you.