

Advancing Exposure Science

ES21 Progress Report: 2016



**Executive Summary**

Over the past year the ES 21 Federal Working Group has made significant progress in meeting the challenges posed by the National Academies, in their report, [*Exposure Science in the 21st Century: A Vision and a Strategy*](http://www.nap.edu/catalog.php?record_id=13507).[[1]](#footnote-1) The ES21 FWG continues to focus on cross-government efforts to identify efficiencies and collaborative opportunities in the area of exposure science.  The five main recommendations identified in the NAS report continue to serve as the strategic roadmap for the ES21 FWG’s work.

Building on the foundational work of the previous years, the ES21FWG has expanded its reach and has moved from organizational and outreach activities to operational strategies and projects. With the ES21 FWG in place, the advantages of collaboration across the Federal Government have become even clearer. New innovative solutions to real world problems now have the benefit of cross-agency expertise and resources.

The ES21FWG is preparing a series of case examples on emerging issues with a strong focus on the importance of exposure information and assessment. These case examples pull together the approaches and outcomes of multiple agencies, each tasked with different aspects of studying and managing emerging exposure problems into individual reports. These case examples will serve as roadmaps for how new advances in exposure science can be used to address complex public health and environmental issues.

This year the ES 21 FWG opened discussions with the *Chemical Toxicity and Assessment Workgroup* about how to most effectively coordinate in the areas where the two groups’ charters intersect. Although the two groups have distinct purposes and expertise, the exposure science component of each is deeply interdependent. By strengthening our exchange of knowledge and data we will facilitate member agencies to excel at their individual strengths while ensuring a consistent and efficient use of Federal resources.

The ES21 FWG has developed a website to provide an overview of sensor-related SBIR funding opportunities across Federal agencies, including solicitation dates, award types and dollar amount. The U.S. Government is a significant driver of sensor innovation including investing in low cost, portable, easy-to-use technologies to facilitate the collection of real time, reliable measurement information. This website is already being used to identify collaborative opportunities, and to maximize information sharing and cost sharing across the Federal partners.

These are just a few examples of progress being made by the ES21FWG. The more complete report provides much more detail on these as well as many other accomplishments to date. In a resource constrained environment, the collaborative component of these groups will ensure wise use of resources and reduce duplication of effort and maximize the sharing of exposure related data and information.

**What is Exposure Science in the 21st Century (ES21)?**



Exposure Science in the 21st Century (ES21) is both a vision for the future of exposure science, and a strategy for using new technologies and strategic collaborations to move the field forward. It challenges exposure science to evolve while continuing to prevent and mitigate adverse exposures to human and ecosystem health. As reflected in Figure 1, exposure science for the 21st century connects sources with other factors to better understand critical outcomes.

Figure 1 - Core Elements of Exposure Science, Reproduced from [NRC (2012](https://ehp.niehs.nih.gov/1206170/#r12))

**Background:** In 2010, EPA, with support from National Institute of environmental Health Sciences (NIEHS), requested that the National Academies, as independent advisers on scientific matters, develop a long-range vision for exposure science in the 21st century and a strategy for implementing this vision over the next twenty years. The report, [*Exposure Science in the 21st Century: A Vision and a Strategy*](http://www.nap.edu/catalog.php?record_id=13507), (ES21) was released in 2012 by the National Academies.[[2]](#footnote-2) The ES21 vision and strategy report recommended that the Federal Government lay the groundwork for a transformational change in the breadth and depth of exposure science that would lead to enhanced integration with the parallel sciences of toxicology and epidemiology.

The ES21 report outlined a framework for advancing exposure science to study how humans and ecosystems interact with chemical, biological, and physical stressors in their environments. The report also described scientific and technologic advances needed to support the long-range vision for exposure science in the 21st century and concluded with a discussion of the elements needed to realize it. The report identified five main recommendations for advancing exposure science. These included:

* Using state-of-the-art methods and technologies such as remote sensing and global positioning to gather exposure information.
* Incorporating advances in genomic technologies and informatics to systematically assemble the vast amounts of different exposure data types.
* Engaging stakeholders who want to contribute exposure data and studies.
* Coordinating exposure research through a formal collaboration with other Federal agencies.
* Training and educating the next generation of exposure scientists.

**Federal Response to “**[**Exposure Science in the 21st Century: A Vision and a Strategy**](http://www.nap.edu/catalog.php?record_id=13507)**”**

In 2014, in response to recommendations in the ES21 report, EPA and NIEHS convened a workshop of Federal agency representatives to raise awareness about the report, discuss and understand the key recommendations in the report and identify aspects of exposure science that would benefit from coordination across Federal agencies. Since that time, the Exposure Science in the 21st Century Federal Working group (ES21 FWG) has been established to expand Federal partnerships, to create a common understanding of exposure science and to drive research across the Federal Government. The Work Group is chartered under the Toxics and Risk (T&R) Subcommittee of the Executive Committee on Environment, Natural Resources, and Sustainability.

The ES21 FWG is composed of over 20 Federal organizations with a vision to interface with other Federal and private-sector groups, including academia and industry. The group serves to optimize resources directed toward exposure science by:

* Identifying and coordinating exposure science research activities for the near-, mid-, and long-term.
* Identifying innovation to modernize methods and optimize the use of exposure data.
* Developing a prioritized list of activities and research collaboration that could substantially modernize and promote the use of exposure science.

With the ES21 FWG in place, the advantages of collaboration across the Federal Government have become even clearer. New innovative solutions to real world problems now have the benefit of cross-agency expertise and resources. Being able to include community engagement will make exposure science responsive to citizen’s needs.

The ES21 FWG has put in place a multipronged approach for advancing exposure science as recommended in the NAS report. This includes: 1) the development of technologies to characterize exposure, 2) the development of data and knowledge management tools to analyze and interpret exposure, and 3) the integration of stakeholders in the research enterprise to enhance the relevance and translation of the research.

**Structure and Focus Areas of the ES21 Working Group**

The ES21 Working Group continues to focus on cross-government efforts to identify efficiencies and collaborative opportunities in the area of exposure science. The five main recommendations identified in the NAS report continue to serve as the strategic roadmap for the ES21 FWG’s work.

The group now consists of representatives from different Federal organizations who share an interest in exposure science research and development. Based upon early discussions and identification of exposure science activities underway in each of the partner organizations, six subgroups of the ES21 FWG were formed to address collaborative opportunities and challenges. In the past year, each of these groups has made significant progress in further refining the emerging challenges and needs of exposure science, identifying short, mid- term and long term research needs and developing an effective inter-agency forum for collaboration. A communications team supports the work of the ES21 FWG.

**ES21 Federal Working Group Organizational Structure**

***Biomonitoring:***
This subgroup is assessing ongoing biomonitoring strategies to identify refinements that may be necessary to make them more effective and accurate. The workgroup is charged with reviewing the National Research Council recommendations and developing options for new biomonitoring approaches that may be more useful than traditional approaches and improvements to traditional biomonitoring approaches with a specific focus on greater utilization of biomonitoring to assess exposure and risk.

***Environmental Monitoring:***

This subgroup is focusing on developing (1) Options for novel environmental monitoring approaches that enable faster identification of chemical, biologic, and physical stressors that are affecting humans and/or ecosystems; (2) Exposure-related environmental monitoring that will help to identify the largest knowledge gaps and reveal where gathering more exposure information would contribute reducing uncertainty; and (3) Monitoring and collection of data, in a variety of ecological and human settings, which contribute to the development of exposure science decision-making tools.

***Community Engagement and Citizen Science:***
This subgroup is focusing on developing strategies to engage communities in furthering the development of exposure science. The National Research Council has made clear that “to maintain public confidence in the integrity of exposure science, innovative forms of public engagement are required.” The “public” is both the user and the generator of exposure data.

***Data Management*:**
This subgroup is reviewing the current status of policies and procedures associated with exposure data collection, analysis and sharing. They are also identifying critical needs and opportunities to partner across the government with the goal of establishing a common set of standard operating procedures that can facilitate the sharing and utilization of existing and future exposure data.

***Modeling:***
This subgroup is assessing current models to determine what refinements are needed to make them more effective. This group is also charged with reviewing the recommendations of the National Research Council, and developing options for new modeling approaches that may be more effective than older approaches. Exposure models must balance the need for transparency with the need for fidelity and credibility.

***Sensors / Dosimeters*:**
This subgroup is (1) Reviewing the recommendations of the National Research Council; (2) Taking inventory of current and emerging tools and gaps; and (3) Developing options for new approaches that may enhance or replace older approaches. New challenges and new scientific advances mean that an expanded, integrated vision of exposure science is necessary—one that considers exposures from source to dose, over time and space, and accounts for multiple stressors from molecular to ecosystem levels. Advanced sensor and dosimeter technology is an important part of this expanded vision.

**Progress in Meeting ES21 Goals and Objectives: 2016**

“Exposure science is used across the Federal Government to inform many important actions. The broad and complex nature of a multi-scale approach to exposure science will require that the core elements of the systems framework shown in Figure 1 are fully developed and integrated. Figure 1 on provides an overview of where various Federal partners are currently working within the framework. Figure 1 nicely illustrates that many of the elements in the framework are being developed across the Federal Government; however, it is apparent that these components need to be brought together to realize the full impact of exposure science in addressing key environmental problems.” [[3]](#footnote-3)

**NAS Perspectives on Progress**

In 2016, the ES21 FWG reached out to one of the original members of the 2012 NAS panel that produced the report on Exposure Science in the 21st Century to ask for an external perspective on the progress that had been made by the ES21 FWG and to solicit ideas on future priorities. Based on an informal review[[4]](#footnote-4) the ES21 FWG was provided valuable feedback that reinforced the directions that the ES21 group has been taking and offered valuable recommendations for future work. The following observations were made regarding progress made by the ES21 FWG over the past two to three years.

* The ES21 FWG has created an organizational structure and set of goals that are directly responsive to the NAS report.
* The ES21 FWG goal are responsive to key recommendations in the report.
* A number of key products from the ES21 FWG have been developed and others are beginning to take shape.
* Efforts to survey and compile exposure science efforts across the Federal partnership have been successful.
* Internal communication is great and has been effective.
* Organizing around topical working group concepts has been a success.
* Exposure science glossary has been very effective in focusing topics.
* Small Business Innovation Research (SBIR) efforts and outreach have been successful.
* Work on collaborative case examples is taking shape and will be instrumental in moving ES21 efforts forward.

**Examples of Cross Cutting ES21 FWG Accomplishments**

***Exposure Science Collaborative Case Examples***

The ES21 FWG has initiated the development of a series of key case examples on emerging issues with a strong focus on the importance of exposure information and assessment. These case examples pull together the approaches and outcomes of a multitude of agencies, each tasked with different aspects of studying and managing emerging exposure problems, into a single report. These case examples demonstrate a collective Federal ability to rapidly make multifaceted scientific inquiry and respond to environmental concerns. These case examples will be published in FY’17 and will serve as roadmaps for how new advances in exposure science can be used to address complex public health and environmental issues. These case examples will focus on chemical-specific risk assessments, emergency response scenarios and the design and development of sensor technologies. With the case examples, one of our key goals is to develop a logistical process to implement key learnings for future.

***Collaboration with the Chemical Toxicity and Assessment Workgroup***

The ES21 FWG has opened discussions with the *Chemical Toxicity and Assessment Workgroup* about how to most effectively coordinate in the areas where the two groups’ charters intersect. Although the two groups have distinct purposes and expertise, the exposure science component of each is deeply interdependent. By strengthening our exchange of knowledge and data, we will facilitate member agencies to excel at their individual strengths while ensuring a consistent and efficient use of Federal resources.

***iOS-based Sound level meter application***

NIOSH hearing loss researchers collaborated with an app developer, EA LAB, to create an iOS based sound level meter app that measures and characterizes occupational noise exposure similar to professional instruments. The app can serve as a tool to raise workers’ awareness about noise in their work environment and help them make informed decisions about the potential hazards to their hearing. In addition, the app can serve as a research tool for scientists and occupational safety and health professionals to collect noise exposure data and promote better hearing health and prevention efforts.

NIOSH estimates that there are 22 million workers who are exposed to hazardous noise levels every year. In addition to damaging workers’ quality of life, occupational hearing loss carries a high economic price to society. NIOSH researchers evaluated hundreds of smartphone apps and published the results in peer-reviewed journals. During the course of the studies, NIOSH realized that most of the apps on the market are oriented at the casual user and lack the accuracy and functionality necessary to conduct occupational and general purpose noise measurements. For more detailed information on these studies, see the NIOSH Science Blog “So How Accurate Are These Smartphone Sound Measurement Apps?” (<http://blogs.cdc.gov/niosh-science-blog/2014/04/09/sound-apps/>).

***Ethics Blog***

Advances in technology are enabling a new generation of wearable sensors. As part of its NIOSH Science Blog, the National Institute for Occupational Safety and Health has posted a new blog on Wearable Sensors: An Ethical Framework for Decision-Making. The blogs provide an opportunity to exchange ideas on various workplace safety and health topics with leading NIOSH researchers. The ethical framework for sensor use described in this blog can be a helpful decision-making tool as stakeholders and researchers seek to move forward with promising technologies in a responsible and accountable manner. Interested individuals are invited to use the blog to share their thoughts on this approach to the ethical use of sensors and sensor data, as well as their experiences on how sensors are being used, or where they are needed to improve the of worker safety, health, well-being and productivity. All are invited to share this information about the blog with everyone they feel would be interested.

***Sensor Technology for the 21st Century***

The U.S. Government is a significant driver of sensor innovation, investing in low cost, portable, easy-to-use technologies to facilitate the collection of real time, reliable measurement information. Federal partners have ongoing Small Business Innovation Research (SBIR) programs that have included requests for proposals related to monitoring, including sensor technology.  However, these requests have not been coordinated in the past and the overall Federal investment has not been captured, nor has there been a consistent Federal-wide message about the interest in and utility of sensor technology. The ES21 FWG has developed a website (hosted by the Small Business Administration (SBA)) to provide an overview of sensor-related SBIR funding opportunities across Federal agencies, including solicitation dates, award types (grant or contract), and dollar amount. This web page on sensor technology is designed to help sensor developers locate SBIR and/or Small Business Technology Transfer (STTR) funding opportunities across Federal agencies: <https://www.sbir.gov/Sensor-technology-for-the-21st-century>.

***Tire Crumb Collaboration***

On February 12, 2016, the U.S. Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry (ATSDR), and the Consumer Product Safety Commission (CPSC) launched a multi-agency Federal Research Action Plan on Recycled Tire Crumb Used on Playing Fields and Playgrounds to study key environmental and human health questions. Concerns have been raised by the public about the safety of recycled tire crumb used in playing fields in the United States. Limited studies have not shown an elevated health risk from playing on fields with tire crumb, but the existing studies do not comprehensively evaluate the concerns about health risks from exposure to tire crumb. This coordinated Federal action includes outreach to key stakeholders, such as athletes and parents, and seeks to fill important data and knowledge gaps, characterize constituents of recycled tire crumb, and identify ways in which people may be exposed to tire crumb based on their activities on the fields.

On December 30, 2016, the agencies released a [status report](https://www.epa.gov/chemical-research/december-2016-status-report-federal-research-action-plan-recycled-tire-crumb) describing the progress of the research to date. The status report includes the final peer-reviewed Literature Review/Gaps Analysis report and describes the progress to date on other research activities that are part of the effort including:

* Characterization of the chemicals found in tire crumb.
* Characterization of the exposure scenarios for those who use turf fields containing tire crumb.
* Study to better understand how children use playgrounds containing tire crumb.
* Outreach to key stakeholders.

The results of the synthetic turf field’s research will be available later in 2017.

**ES 21 Subgroups: Progress and Accomplishments**

**Biomonitoring Subgroup:** Co-Chairs Mary Mortensen (CDC/NCEH) and Andrea Pfahles-Hutchens (EPA/OCSPP)

***Charter***

 Monitoring of exposure to stressors can play many roles including determination of stressor presence, stressor type and stressor level. With few exceptions, however, monitoring techniques do not provide the quantitative information needed for use in exposure assessment. There is an ever increasing need for development and collection of different types of biological markers and environmental indicators of exposure. The workgroup will assess ongoing strategies to determine what refinements may be necessary to make them more effective and accurate. The workgroup is charged to review the recommendations of the NRC and develop 1) Options for new approaches that may be more useful than traditional approaches; and 2) Improvements to traditional approaches with a specific focus on greater utilization of biomonitoring to assess exposure and risk.

***The Biomonitoring Challenge***

New challenges and new scientific advances mean that an expanded, integrated vision of exposure science—one that considers exposures from source to dose, over time and space, to multiple stressors, and from the molecular to ecosystem level—is now needed. This vision is defined as the extension of exposure science from the point of contact between stressor and receptor inward, into the organism; and outward, to the general environment including the ecosphere. This group has focused on the challenges presented including lack of knowledge and techniques, including:

* Biomarkers and Biomonitoring Techniques (front and back end of the regulatory process).
* Improved use of Biomonitoring to evaluate & reconstruct exposure.
* Linking exposures to ecological and human health outcomes.

***Accomplishments in 2016:***

* **Biomonitoring Data Collection and Application**

The Biomonitoring Subgroup designed and administered a cross agency survey to better understand how biomonitoring data are used and generated at Federal Partners’ Agencies. The survey was designed to inform the Biomonitoring Subgroup about current activities of subgroup members’ agencies and to help focus future activities of the subgroup as well as to continue to foster collaboration among member agencies. Survey questions included:

* Does your agency conduct/carry out human biomonitoring (defined as measurement of a chemical/metabolite/reaction product in human specimens)? If "yes" briefly describe the types of data that you generate, if they are publicly available, and how they are used by your agency.
* Does your agency use biomonitoring data? If so, please describe how it is used (describing trends, risk assessment, support regulatory decisions, PBPK modeling, etc.). What sources of data does your agency use? Please provide an example(s) of how the data are used.
* Are there biomonitoring data that would be useful to your agency but are not currently available? If so, please describe.
* Would you be willing to present this information in a webinar to the subgroup?

Results of this survey have been collated and shared with the subgroup to use for future collaboration efforts and to identify potential future webinars. Over the coming year the results will be further refined and may be shared more broadly.

* **Webinars**

A number of key topic webinars were initiated and led by the Biomonitoring Subgroup:

* CDC Chemical Threats and the Laboratory Response Network. Dr. Rudy Johnson (Emergency Response Branch, DLS, NCEH, CDC) presented a webinar on the CDC Chemical Threats and the Laboratory Response Network. CDC partners with the Laboratory Response Network-Chemical (LRN-C), a national network for responding to chemical terrorism and other public health emergencies. LRN-C integrates 54 state and local public health laboratories that operate 24/7 to provide laboratory diagnostics and the surge capacity for chemical emergencies.
* Consumer Product Safety Commission’s Nanotechnology Activities Dr. Treye Thomas, the Chemical Hazards Program Leader, presented a webinar on the Consumer Product Safety Commission’s nanotechnology activities.
* Biomonitoring activities and applications at NIOSH. Dr. Gayle DeBord (Associate Director for Science, Division of Applied Research and Technology, NIOSH) presented a webinar describing biomonitoring activities and applications at NIOSH.
* **Collaborations**

The Biomonitoring Subgroup continued to build establish partnerships across the biomonitoring community. Examples of new collaborations include:

* Sharing of contacts and information on various topics that were discussed during subgroup meetings. For example, sources of information and contacts within various agencies were shared on a topic involving the use of plastic pipes in water distribution systems in California.
* Organizers of a USGS workshop on water and human health invited several Biomonitoring subgroup members to participate in developing funding proposals that would use USGS ground and surface water data and human biomonitoring and health data. One proposal would use environmental and human data sources in a novel effort to examine U.S. population exposure to environmental chemicals from contaminated water.

**Environmental Monitoring Subgroup (EMS):** Chair: Michael McDonald (EPA/ORD) and Kathy Lee (USGS/TSHP)

***Charter***

Environmental monitoring describes the processes and activities that need to take place to characterize and monitor the quality of the environment. Exposure science examines the complex relationship between the interaction with a stressor and receptor over a period of time. Environmental monitoring enables exposure scientists to characterize and understand stressor fate and transport in a variety of ecosystems.

The subgroup is charged to review the recommendations of the NAS report Exposure Science in the 21st Century and develop (1) Options for novel environmental monitoring approaches that enable faster identification of chemical, biologic, and physical stressors that are affecting humans and/or ecosystems; (2) Exposure-related environmental monitoring that will help to identify the largest knowledge gaps and reveal where gathering more exposure information would contribute reducing uncertainty; and (3) Monitoring and collection of data, in a variety of ecological and human settings, which contribute to the development of exposure science decision-making tools.

***The Environmental Monitoring Challenge***

Effective environmental monitoring is subject to a range of institutional, political, and legal constraints. Cultural and organizational changes over the last few decades have resulted in fewer resources available for environmental monitoring. These constraints require development of a more coordinated, efficient and technological approach to monitoring. Even if effective monitoring data is gathered, it may not be used in decision making. Uncertainty associated with monitoring data allows stakeholders to contest the use of monitoring in decision making. New monitoring systems and partnerships are needed across government, states and regional/local levels to produce high quality data and information for decision makers.

***Accomplishments in 2016:***

* **Methods Development and Alternative Approaches**

The Environmental Monitoring Subgroup (EMS) has encouraged the development of a systematic method to utilize georeferenced data from the Water Quality Portal (>200 M data points) and other agency data bases including landscape level data in EnviroAtlas, a publicly available EPA/ORD website and mapping application, to develop a national scientific data and mapping tool for integrating and displaying the water chemistry and associated ancillary data for the ultimate goal of understanding human and other organism exposure. EMS is not developing a database, but rather providing suggestions for a method to mine existing data bases that are georeferenced and can be queried and displayed in a web-based mapping application. The intent is to develop a systematic method to bring together Federal data sources into an interface that allows the user to query geo-referenced data for a site(s) to determine potential physical, chemical, and microbial stressors, and display it on web-based mapping application for the location. Similarly, the method will allow a user to determine how widespread a selected stressor(s) is across the country and also display it on a web-based mapping application. EMS is starting with two existing web-based applications (EnviroAtlas and the Water Quality Portal) to begin this effort.

EMS has also explored alternative approaches to environmental monitoring of wildlife in relation to spatially explicit hazardous waste sites. EMS members have offered a novel and challenging perspective on chemical exposures in ecological risk assessment in a seminar entitled "Ecological Exposure Science in a New Light." Looking at mammalian exposure through biomonitoring, as opposed to modeling, this approach may enhance future cross-over discussions with the Biomonitoring Subgroup.

* **Webinars**

A number of key topic webinars were initiated and led by the Environmental Monitoring Subgroup.

* [Nationwide Soil Geochemical data](https://minerals.usgs.gov/science/application-soil-data-conterminous-US/index.html#content) from the USGS Mineral Resources Program, (Peter Schweitzer, USGS).
* USGS/EPA/National Water Quality Monitoring Council on Water Quality Data (Nate Booth and Jim Kreft from USGS.
* [The Water Quality Portal](https://www.waterqualitydata.us/): A single point of access for national scale, multi-agency water quality data.
* National mapping of multiple, integrated datasets (Annie Neale, EPA).
* [EnviroAtlas](https://www.epa.gov/enviroatlas): Encouraging a Systems Approach through Better Data Access, Integration and Visualization.

**-   Data Collection Activities**

EMS has also been instrumental in the development of the “Pet Health Survey” a citizen science approach to assessing the spatial and temporal trends in pet (dogs and cats in the current survey) diseases/health issues in residential settings and identify areas where pet disease is prevalent within the U.S. EMS is pursuing NGO, industry and Federal collaborators and cooperators to host the survey on their websites and share the collected information with the broader ES21 community. The intent is for these data to be summarized, mapped and made readily available via an easy-to-use web application, closing the information loop to the citizen scientists. The data collected from this survey can help to identify areas of the country where pet health issues may be linked to contaminant exposures from the environment. As humans and their pet companions spend time in similar environments, these data could have important implications for human exposures and adverse outcomes as well. Once collected, the data will be assessed for linkages to possible exposures routes including drinking water, water quality, food consumption, inhalation and dermal contact.

**Sensors / Dosimeters Subgroup:** Tim Watkins (EPA/ORD)

*****Charter***

Remote sensing has emerged as a key innovation in exposure science. Remote sensing has been defined as the “acquisition and measurement of data/information on some properties of a phenomenon, object, or material by a recording device. New tools are needed to facilitate the collection of real time, reliable exposure information. The workgroup is charged to review the recommendations of the NRC, inventory current/ emerging tools and gaps, and develop options for new approaches that may enhance or replace older approaches.

***Description of the Sensor / Dosimeter Challenge***

New challenges and new scientific advances mean that an expanded, integrated vision of exposure science—one that considers exposures from source to dose, over time and space, to multiple stressors, and from the molecular to ecosystem level— is now needed. This vision is defined as the extension of exposure science from the point of contact between stressor and receptor inward, into the organism; and outward, to the general environment. To improve data quality for Remote Sensing and increase its utility for exposure studies, technologic improvements are needed.

***Accomplishments in 2016:***

* **SBIR Website**
* The SBIR Sensors website was officially launched in 2016 The website (hosted by SBA) provides an overview of sensor-related SBIR funding opportunities across Federal agencies, including solicitation dates, award types (grant or contract), and dollar amount. <https://www.sbir.gov/Sensor-technology-for-the-21st-century>. This web page on sensor technology is designed to help sensor developers locate SBIR and/or STTR funding opportunities across Federal agencies. The U.S. Government is a significant driver of sensor innovation, investing in low cost, portable, easy-to-use technologies to facilitate the collection of real time, reliable measurement information.
* **Input to the EPA/ECOS E-Enterprise Advanced Monitoring subgroup**
* The Sensors group provided input to the EPA/ECOS E-Enterprise Advanced Monitoring subgroup on potential options for 3rd party sensor certification programs. A report on third party certification options has been developed and will soon be presented to the EPA/ECOS E-Enterprise Executive Leadership Council (EELC).
* **Presentation at the 2016 ISES Conference**
* The Sensors Subgroup developed a presentation for the 2016 ISES Conference in Utrecht, Netherlands in collaboration with international partners from EuNetAir.  The presentation was entitled “Advancing exposure science through technology: Focus on Sensors” and focused on the importance of collaboration in advancing sensors technology and provided examples of collaborations in the development of sensor technology, evaluation and certification of sensor technology, and education and outreach.
* **The Sensors Sub group worked on a number of other efforts to expand the knowledge base regarding the new ES21 effort. These included:**
* America Industrial Hygiene Association (AIHA) Webinar - Presented information and activities for the ES21 Federal Partners group and the Sensors and Dosimeters subgroup in a webinar hosted by AIHA on sensor technologies.  Other participants in NIOSH and the National Nanotechnology Coordination Office (NNCO).
* Case examples - Contributed to the development of two case examples (still in progress) to highlight the potential role of sensor technologies in advancing exposure science. The first case study relates to the Disaster Preparedness and the second address the role of technology in advancing exposure science.

As the ES21 Sensors and Dosimeters Subgroup moves forward, the ultimate goal will be to enhance precision of exposure assessment for health and ecosystem risk assessments. In the near term, the focus will be on the development and evaluation of real-time monitoring tools to improve the precision of spatial and temporal measurements of exposure and internal dose for variety of environmental contaminants. Furthermore, there is strong consensus that there is a near term need for the development of technical guidance/performance specifications for emerging technologies so that the potential uses for these approaches may be fully realized. In the longer term, issues of big data will need to be considered, as well as the integration of data from these emerging technologies with data from more established and traditional methods. An example of future work of the sensors group is a wildland fire sensors challenge.

* **Wildland Fire Sensors Challenge**

Federal, state, local, and tribal agencies are interested in new ways to monitor air quality during fire events to better protect public health. Air quality managers and public health officials have limited access to accurate information on ground-level air pollution levels in the vicinity of wildland fires, making it difficult to provide appropriate strategies to minimize smoke exposure. This challenge seeks a field-ready prototype system capable of measuring constituents of smoke, including particulates, carbon monoxide, ozone, and carbon dioxide, over the wide range of levels expected during wildland fires. Written submissions are due November 22, 2017. More information on the challenge is available at <https://www.challenge.gov/challenge/wildland-fire-sensors-challenge>. ES21 Federal partners also recently published a journal article entitled “Community vulnerability to health impacts of wildland fire smoke exposure” in the journal of Environmental Science and Technology. The article is available at <http://pubs.acs.org/doi/abs/10.1021/acs.est.6b06200>.

**Models Subgroup*:*** Andy Gillespie (EPA/ORD) and Jodi Ryder (USACE/ERDC)

***Charter***

Exposure models will continue to support diverse efforts such as risk analysis, impacts assessment, life cycle and sustainability assessments, epidemiology and energy analysis. Models for screening, prioritization, and prediction need to be developed and validated. Exposure models must balance the need for transparency with the need for fidelity and credibility. Models need to be backed up by data to be acceptable. The workgroup will assess current models to determine what refinements may be necessary to make them more effective. The workgroup is charged to review the recommendations of the NRC and develop options for new approaches that may be more effective than older approaches.

***Description of the Modeling Challenge***

New challenges and new scientific advances mean that an expanded, integrated vision of exposure science—one that considers exposures from source to dose, over time and space, to multiple stressors, and from the molecular to ecosystem level— is now needed. The NRC Committee identified the need for the further development of existing and emerging methods and approaches, validation of methods and their enhancement for application on different scales and in broader circumstances and improved linkages to research in other areas of environmental health. Models of the processes, dynamics and distribution of exposures to chemical, physical, and biologic agents in association with other stressors are an essential element of exposure science. The challenge for this group is to consider the role that exposure models need to play in supporting exposure science in the 21st century and identifying the gaps that need to be filled.

***Accomplishments in 2016:***

* **Collaboration on Modeling Capability and Capacity**
* The Modeling Subgroup has developed a strategy to collect and present information on ES21 related models across multiple disciplines and agencies. This effort will allow agencies to work collaboratively and maximize the use of both capability and capacity across the Federal Government

**Data Management Subgroup:** Sam Glover (CDC / NIOSH) and Vasu Kilaru (EPA)

***![C:\Users\Susan\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.IE5\IKUVY6X9\MC900438780[1].jpg]()Charter***

 There is a compelling need for the development of Policies and Standard Operating Procedures for the collection and management of exposure and exposure-related data. In the near term, exposure science needs to develop strategies to expand exposure information rapidly to improve understanding of where, when, and how exposures occur and their health significance. Data generated and collected would be used to evaluate and improve models of exposure for use in generating hypotheses and developing policies. This data collection and management group is tasked to review the current status of policies and procedures associated with exposure data, and to identify critical needs and opportunities to partner across the government to establish a common set of standard operating procedures to facilitate the sharing and utilization of existing and future exposure data.

***Description of the Data Management Challenge***

New challenges and new scientific advances mean that an expanded, integrated vision of exposure science—one that considers exposures from source to dose, over time and space, to multiple stressors, and from the molecular to ecosystem level— is now needed. This vision is defined as the extension of exposure science from the point of contact between stressor and receptor inward, into the organism; and outward, to the general environment including the ecosphere. Numerous challenges in the area of data management have been identified and will serve as the starting point for this group. These include:

|  |  |
| --- | --- |
| * Management Across Heterogeneous Sources
* QA/QC
* Linkages
* Availability of Existing data
* Ethics of using data
* Accessibility of Data
 | * Current Data
* -how to access, use and integrate
* Methods for collecting, handling and analyzing “big data” from multiple sources
* Consistency Across the Federal Government
* Terminologies
* Platforms
 |

***Accomplishments in 2016:***

* **NIEHS CHEAR initiative**
* NIEHS is working on an extending the exposure ontology originally developed by Carolyn Mattingly (NCSU).  One of the goals of this effort is to have a data science repository, analysis, and science center.  This center will not only house data but also help develop community based data/metadata standards.  This infrastructural is more broadly applicable and is the type of work that needs to be done in order to advance the data driven aspects of exposure science.
* **SHEDS-HT SHEDS (Stochastic Human Exposure and Dose Simulation**
* SHEDS-HT SHEDS has a new component called SHEDS-HT (high throughput). This is an effort at EPA to extend integrate probabilistic exposure to prioritizing exposure to near field chemicals from consumer products and dietary sources. This effort has been designed to complement the high throughput efforts in computational toxicology and provide critical exposure inputs for risk assessment.
* **AEP - Development of the Aggregate Exposure Pathways (AEP) framework.**
* The AEP is an exposure analog to the Adverse Outcomes Pathway (AOP) and is meant to encompass the exposure regime from source to internal dose to the molecular initiating event. It offers an organizational framework for data driven exposure assessment and prediction. Implicit to this effort is a data architecture and infrastructure to support the AEP that will be in keeping with the needs of ES21 to advance exposure science into the 21st century.
* **Public Access to Data**
* The Data Subgroup is working with Federal partners to identify effort to expand public access to data and has been closely monitoring agency public access plans as required by the Holdren directive[[5]](#footnote-5).

**Community Engagement/Citizen Science Subgroup:** Liam O’Fallon (NIH / NIEHS) and Ed Washburn (EPA / ORD)

***Charter***

The Community Engagement/Citizen Science workgroup will focus on developing strategies to engage communities in furthering the development of exposure science. The NRC has made clear that “to maintain public confidence in the integrity of exposure science, innovative forms of public engagement are required.” The public can be the user and generator of exposure data. The new approaches must be embraced by the public if they are to become key players. The group should identify new opportunities and approaches for encouraging the public to identify and address relevant health concerns at the local level. Assessing ongoing strategies and identifying new approaches to engage citizens before, during and after exposure studies is of critical importance for success. The workgroup will assess ongoing strategies to determine what refinements may be necessary to make them more effective. The workgroup is charged to review the recommendations of the NRC and develop options for new approaches that may be more effective than older approaches.

***Description of Challenge***

New challenges and new scientific advances mean that an expanded, integrated vision of exposure science—one that considers exposures from source to dose, over time and space, to multiple stressors, and from the molecular to ecosystem level— is now needed. This vision, dubbed “the eco-exposome,” is defined as the extension of exposure science from the point of contact between stressor and receptor inward, into the organism; and outward, to the general environment including the ecosphere. Effective implementation of the committee's vision will depend on the development and cultivation of scientists, engineers, and technical experts with experience in multiple fields, in order to educate the next generation of exposure scientists and to provide opportunities for members of other fields to cross-train in the techniques and models used to analyze and collect exposure data. This includes the need for the development of programs to improve public understanding and engagement in exposure-assessment research, including ethical considerations involved in the research.

***Accomplishments for 2016:***

* **Research Triangle Environmental Health Collaborative**

# The Research Triangle Environmental Health Collaborative (RTEHC) provides the convening structure that connects organizations and institutions; links research and policy; and joins government, academia, industry, and public interest groups to mutually consider, discuss, and debate the future of environmental health on a regional, national, and international level. The RTEHC brings together all interested stakeholders including states, communities, academia, industry and the Federal Government. Specifically, for the Federal sector, the RTEHC can:

* Assist in facilitating agency/institute goals (e.g., organize meetings, attract new scientists, serve as a clearinghouse for activities and events in the area).
* Promote collaborations between government and non-government stakeholders.
* Serve as a convener of national and international experts on topics of interest.
* Provide expert advice and review.
* Address multiple agency missions at one time, in one setting.
* Provide a neutral forum for discussions on science and policy.
* Assure visibility for key environmental programs.
* Advance influence to stakeholders outside of the Federal Government.

In December 2016, the RTEHC convened a summit: Community Engaged Research and Citizen Science - Advancing environmental public health to meet the needs of our communities. The purpose of this workshop was to advance the conversation around exposure science and citizen science. The summit acknowledged the successful projects and approaches that reflect the recommendation from the ES21 report, identified new opportunities, and considered the application of citizen science in the context of environmental health disparities and additional dimensions.

* NIEHS Environmental Health Science FEST

### In December 2016, as part of its 50th anniversary celebration, the National Institute of Environmental Health Sciences (NIEHS) brought together researchers, trainees, young investigators, community partners, and stakeholders from across the United States to discuss past accomplishments and explore the future of environmental health science in the 21st century.  As part of the event, NIEHS sponsored a Sensors and Technologies Fair. The EHS Sensors and Technologies Fair was an opportunity for over 30 sensor and technology developers, funded by NIEHS and other agencies, to showcase their cutting-edge technologies and meet with leading scientists and end-users in exposure science, environmental epidemiology, community research and citizen science.

**FY ’16 -17 and beyond for the ES21 Federal Working Group**

“A very significant benefit of the NAS report is that it has served as an impetus for Federal agencies that need and use exposure science for environmental and public health decision-making to do so in a leveraged manner. Exposure science is used across the Federal Government to inform many important actions. The broad and complex nature of a multi-scale approach to exposure science will require that the core elements of the systems framework shown in Figure 1 are fully developed and integrated. Figure 1 provides an overview of where various Federal partners are currently working within the framework and illustrates that many of the elements in the framework are being developed across the Federal Government; however, it is apparent that these components need to be integrated to realize the full impact of exposure science in addressing key environmental problems.” [[6]](#footnote-6)

The ES21 FWG has established a strong foundation upon which to build for 2017 and beyond. The group will be working on a number of high priority efforts and will be continuing to build partnerships and leveraging collaboration across the Federal Government. A number of the focus areas for 2017 and beyond include:

* Cross Agency and Cross Discipline Case (Include topic areas). These case examples will bring together all the components of ES21 effort and will demonstrate the value of the integrated approach of ES21.
* Enhanced and higher level communication and coordination across the Federal partners, including expanding the family of partners. Consideration of expanding the partnership to include academic and other external partners.
* Engagement of senior leaders in developing and supporting strategic goals.
* Linkage of data collection to “infostructure,” informatics and modeling to maximize access and utility of data.
* Focus on scientific and regulatory challenges that ES21 is best positioned to address
* Development of guidance on new ES21 approaches.
* Development of products such as compendiums of ES21 models and other sources of data.
* Continued work on collaborative work on perfluorinated compounds (PFC’s) including the development of sensitive analytical methods to better detect PFC’s.
* EPA-NIEHS-CPSC partners will continue their work on tire crumb issues moving forward to better assess gaps in the science.

For more information on the ES21 Federal Working Group, contact one of the following two co-chairs.

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 Appendix A



CHARTER

of the

WORKING GROUP ON EXPOSURE SCIENCE FOR THE 21st CENTURY TOXICS AND RISK SUBCOMMITTEE

COMMITTEE ON ENVIRONMENT, NATURAL RESOURCES, AND SUSTAINABILITY

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

**A. Official Designation**

The Working Group on Exposure Science for the 21st Century (ES21) is hereby established by action of the National Science and Technology Council (NSTC); Committee on Environment, Natural Resources, and Sustainability (CENRS); Toxics and Risk Subcommittee (T&R).

**B. Purpose and Scope**

Exposure science investigates the contact of humans or other organisms with chemical, physical, and biologic stressors, and their fate in living systems. Understanding exposure provides the real­ world context for describing risk, along with information on the most effective ways to reduce exposure and improve health. Exposure science has become more important with the emergence of today's complex problems including climate change, security threats, population pressure, urbanization, depletion of natural resources, and increased understanding of environmentally related illness. This complexity, combined with advances in measurement and computational technologies, provides new opportunities for advancing and using exposure science to address today's wide range of health challenges.

The purpose of the ES21 Working Group is to build on the framework recommended by the National Academy of Sciences in its 2012 report on *Exposure Science in the 21st Century: A Vision and a Strategy,* and promote Federal collaboration in the development of exposure science. The ES21 Working Group will serve to share information, integrate activities, and reduce duplication of efforts across agencies in the development of new exposure science.

**C. Functions**

ES2 will be a forum for Federal agencies to collaborate and advance the field of exposure science and optimize agency resources by:

1) Identifying and coordinating ongoing and planned exposure science research and development activities among Federal agencies in the near-, mid- and long-term in a planning matrix. This matrix will focus on the topics areas of modeling, biomonitoring, sensor technologies, managing data, and community engagement/citizen science.

2) Identifying innovations to modernize methods and optimize the use of exposure data to advance research and development, and applications in science and technology;

3) Developing a prioritized list of activities and research collaborations that could substantially modernize and promote the use of exposure science.

ES21 will coordinate with, and address the needs of, other relevant CENRS Committees and working groups. ES21 will report their findings to the Committee prior to the termination date.

**D. Membership and Structure**

The following NSTC departments and agencies are represented on the ES21 Working Group: Department of Agriculture,

Department of Commerce,

Department of Defense, Department of Energy,

Department of Health and Human Services,

Department of Homeland Security, Department of the Interior, Department of Labor

Department of Transportation,

Environmental Protection Agency,

National Aeronautics and Space Administration; and

National Science Foundation.

The following organizations of the Executive Office of the President are also represented on

ES21:

Office of Management and Budget, and

Office of Science and Technology Policy.

Cooperating departments and agencies shall include other such Executive organizations, departments, and agencies as the T&R Co-chairs may, from time to time, designate. ES21 Co­ chairs and an Executive Secretary shall be appointed by the T&R Co-chairs. The Executive Secretary shall maintain and distribute agendas, minutes, records of action, and products, consistent with NSTC procedures.

**E. Private-Sector Interface**

ES21, in consultation with T&R, may seek advice from members of the President's Council of Advisors on Science and Technology to secure appropriate private-sector[[7]](#footnote-7) advice, and will recommend to T&R, CENRS and/or the President's Science Advisor the nature of any additional non-Federal advice needed to accomplish its mission. ES21 may also interact with and receive *ad hoc* advice from various private-sector groups consistent with the Federal Advisory Committee Act.

**F. Termination**

Unless renewed by the Co-chairs of the T&R Subcommittee prior to its expiration, ES21 shall terminate no later than April 16, 2015.

**G. Determination**

I hereby determine that establishment of the Working Group on Exposure Science for the 21st

Century (ES21) is in the public interest in connection with the performance of duties imposed on the Executive Branch by law and those duties can best be performed through the advice and counsel of such a group.



1. EPA Website : http://www.epa.gov/nerl/features/nrcreport.html [↑](#footnote-ref-1)
2. EPA Website: <http://www.epa.gov/nerl/features/nrcreport.html> [↑](#footnote-ref-2)
3. Exposure Science in the 21st Century: A Federal Perspective [↑](#footnote-ref-3)
4. ES21 Federal Working Group: Perspectives on Progress and Opportunities, Justin G. Teeguarden, PhD, DABT [↑](#footnote-ref-4)
5. <https://cendi.gov/projects/Public_Access_Plans_US_Fed_Agencies.html> [↑](#footnote-ref-5)
6. Exposure Science in the 21st Century: A Federal Perspective [↑](#footnote-ref-6)
7. The Federal Advisory Committee Act, 5 U.S.C. App., as amended, does not explicitly define "private sector," but the phrase is generally understood to include individuals or entities outside the Federal government such as, but not limited to, the following: non-Federal sources, academia, State, local or Tribal governments, individual citizens, the public, non-governmental organizations, industry associations, international bodies, etc. [↑](#footnote-ref-7)