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National Institute for Occupational Safety and Health
NIOSH Docket Office
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On behalf of the Center for Data Innovation (datainnovation.org), we are pleased to submit these comments in response to the National Institute for Occupational Safety and Health's (NIOSH) Center for Direct Reading and Sensor Technologies' request for information on sensors for emergency response activities.[1]

The Center for Data Innovation is the leading think tank studying the intersection of data, technology, and public policy. With staff in Washington, DC and Brussels, the Center formulates and promotes pragmatic public policies designed to maximize the benefits of data-driven innovation in the public and private sectors. It educates policymakers and the public about the opportunities and challenges associated with data, as well as technology trends such as predictive analytics, open data, cloud computing, and the Internet of Things. The Center is a non-profit, non-partisan research institute affiliated with the Information Technology and Innovation Foundation.

Emergency responders increasingly use, or have the potential to use, the emerging set of technologies commonly referred to as the Internet of Things—devices embedded with sensors and connected to the Internet to send and receive data which can be analyzed and acted upon. In this submission, we outline some of the many ways in which the Internet of Things can aid emergency response, ranging from keeping emergency responders safe to avoiding disasters entirely. Additionally, we identify several ways for NIOSH to encourage the effective deployment of the Internet of Things to fully take advantage of the benefits it can offer.

Please find our responses to the relevant questions in the attached document.

[1] "Request for Information on NIOSH Center for Direct Reading and Sensor Technologies: Sensors for Emergency Response Activities," Federal Register, January 19, 2016, https://www.federalregister.gov/articles/2016/01/19/2016-00828/request-for-information-on-niosh-center-for-direct-reading-and-sensor-technologies-sensors-for.

Sincerely,

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CENTER FOR DATA INNOVATION

A. UTILIZATION OF SENSORS IN EMERGENCY RESPONSE

A1. WHAT SENSORS HAVE THE MOST IMMEDIATE IMPACT ON EMERGENCY RESPONSE?

The total economic impact of the Internet of Things on emergency response is difficult to quantify, but many applications show potential to substantially improve emergency response efforts. The most significant impact the Internet of Things can have on emergency response, however, is that it can prevent disasters from happening entirely. Sensors embedded in infrastructure can report data on structural integrity in real time, enabling authorities to perform preventative maintenance if this data indicates the infrastructure might fail. For example, sensor networks embedded in "smart levees" in The Netherlands can warn engineers that a levee will break 42 hours in advance, allowing them to take corrective action.[2] When a disaster is unavoidable, such as with weather-related events, sensors can serve as early warning systems to help minimize their impact. In Utah, sensors placed on highways to monitor road conditions allows state road crews to target areas most in need of intervention, which has reduced the number of car accidents during inclement weather.[3] And some Department of Veterans Affairs hospitals are equipped with movement-detecting sensors that can monitor the structural health of the building during an earthquake and warn hospital administrators if they will need to evacuate patients and staff.[4]

Sensors can provide real-time information to emergency responders to reduce response times in emergencies. For example, networks of satellites with sophisticated cameras and infrared sensors can detect subtle changes on the ground that signal a growing wildfire within hours of its formation, which help emergency responders take action quickly and provide information about the fire's potential trajectory.[5] Additionally, accelerometers and acoustic sensors in consumers' smartphones can be used to detect car crashes and automatically inform emergency responders about the crash and precise location.[6] And in Greenwood, Indianapolis, sensors in emergency response vehicles and traffic lights communicate when a vehicle is approaching a busy

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[2] Adriana Stuijt, "'Smart levees' predict breaks 42 hours in advance," *Digital* Journal, March 21, 2009, http://www.digitaljournal.com/article/269622.
[3] Alan McQuinn et al., "Driving the Next Wave of IT-Enabled State Government Productivity," Information Technology and Innovation Foundation, October 2015, http://www2.itif.org/2015-next-wave-it-state-government.pdf.
[4] "Data Processing," U.S. Geological Survey, February 13, 2012, http://nsmp.wr.usgs.gov/processing.html.
[5] Joshua New, "5 Q's for Arthur Lane, Project Coordinator at FireSat," Center for Data Innovation, January 26, 2016, https://www.datainnovation.org/2016/01/5-qs-with-arthur-lane-project-coordinator-at-firesat/.
[6] Jules White et al., "WreckWatch: Automatic Traffic Accident Detection and Notification with Smartphones," Journal of Mobile Networks and Applications, Accessed March 17, 2016, https://pdfs.semanticscholar.org/9d03/3b54f7b5278952a3c6e0aa4d9f4b08e3030d.pdf.

intersection to change the traffic signals to prevent police cars, fire trucks, and ambulances from getting stuck at a red light.[7] Reducing the time it takes for emergency responders to arrive to a scene can make a significant difference. For example, reducing emergency response times for cardiac arrests from 15 minutes to 5 minutes can double the survival rate.[8]

Sensor technology can also aid emergency response efforts to locate victims after a disaster. For example, sensor technology developed by the Jet Propulsion Laboratory (JPL) at the National Aeronautics and Space Administration (NASA) and the U.S. Department of Homeland Security's Science and Technology Directorate can detect human heartbeats through 30 feet of rubble, which could prove invaluable for emergency responders working to locate people trapped after a building collapse.[9] And while global positioning system (GPS) technology in smartphones can of course help emergency responders identify the longitude and latitude of someone in need of aid, barometric sensors, Bluetooth beacons, and radiofrequency sensors all show promise to help pinpoint someone's position above or below the ground.[10] This type of information could aid emergency response efforts such as identifying where people might be a tall building during a fire or helping locate people trapped underground.

Finally, by embedding sensor technology in protective equipment, emergency response efforts can better monitor and safeguard the health of responders in dangerous environments as well as avoid equipment failure. For example, firefighting clothing and equipment embedded with temperature and air quality sensors can warn firefighters when the area is becoming too hot or smoky for their equipment to adequately protect them.[11] And wearable biometric sensors such as heart rate monitors can provide real-time data to officials about the health of emergency responders allowing them to better support workers in the field and prevent injury.

A2. WHAT APPLICATIONS/SITUATIONS SUCH AS DETERMINATION OF THE NEED FOR EVACUATION, USE OF PERSONAL PROTECTIVE EQUIPMENT, OR END-OF-

[7] Laura Kennedy, "New 'smart intersections' in Greenwood to help emergency response vehicles," *WISHTV*, June 5, 2015, http://wishtv.com/2015/06/05/new-smart-intersections-in-greenwood-to-help-emergency-response-vehicles/.
[8] Jill P. Pell et al., "Effect of reducing ambulance response times on deaths from out of hospital cardiac arrest: cohort study," *BMJ* (2001): 322:1385, http://www.bmj.com/content/322/7299/1385.
[9] Kadhim Shubber, "Heartbeat detector developed by Nasa finds people trapped under rubble," *Wired*, September 11, 20013, http://www.wired.co.uk/news/archive/2013-09/11/heartbeat-rubble-sensor.
[10] Jeff Bratcher, "FirstNet Evaluating Key Indoor Location Technologies to Help Solve 'Z-Axis' Challenges for Public Safety," FirstNet, June 29, 2015, http://www.firstnet.gov/newsroom/blog/firstnet-evaluating-key-indoor-location-technologies-z-axis.
[11] Casey Grant et al., "Research Roadmap for Smart Fire Fighting," National Institute of Standards and Technology, May 2015, http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1191.pdf.

SERVICE-LIFE OF PROTECTIVE EQUIPMENT ARE PARTICULARLY IN NEED OF SENSORS?

The majority of the aforementioned examples are either experimental or have only been deployed in a very limited capacity. Of all the potential applications of sensors to aid emergency response efforts, fully integrating sensors into infrastructure would likely have the largest impact, as it shows substantial potential to both prevent disasters and limit the damage they can cause. As such, efforts to deploy sensors for emergency response should prioritize developing smart infrastructure, including bridges, levees, highways, and buildings.

A3. WHAT ARE SOME ADVANTAGES OF NEWER GENERATION SENSORS OR DIRECT READING DEVICES FOR EMERGENCY RESPONSE?

Advanced sensor technology, such as the heartbeat detecting technology previously mentioned, can provide responders with more useful information than ever before, improving the timeliness, effectiveness, and efficiency of emergency response efforts. However, it is important to note that much of the value of sensors for emergency response comes from widespread deployment of relatively low-tech sensors and advanced analytics performed on the data they generate. For example, moisture and temperature sensors embedded in a stretch of highway prone to freezing are not particularly advanced technologies, but the insight they can provide to road crews in real time can nonetheless be enormously valuable.

In many cases, emergency responders may be secondary, rather than primary, users of sensors which are deployed for other purposes. For example, an air quality sensor may be used for daily neighborhood air quality reports, but be of particular use to emergency responders when responding to an incident. Emergency responders will need to consider how they can partner with the other organizations, in both the public and private sector, to gain access to data that may be useful for them in certain situations, as well as to reciprocate and provide data they collect for use by others. The value of the Internet of Things will expand as the size of the network grows and there are more opportunities to leverage data collected from a wide variety of sources.

A4. COULD WEARABLE OR EMBEDDED SENSORS HAVE A MAJOR CONTRIBUTION? HOW?

Yes. See responses to questions A1, A2, and A3.

A5. WHAT ARE THE PRIMARY STUMBLING BLOCKS THAT IMPEDE SENSOR DEVELOPMENT AND COMMERCIALIZATION (E.G., RELIABILITY, POTENTIAL MARKET SIZE, INVESTMENT CAPITAL, ETC.)?

The development and commercialization of sensors for emergency response faces several obstacles that the public sector can help overcome to accelerate deployment.

Though many sensor technologies could have beneficial emergency response applications, sensor manufacturers may not be aware of these applications or feel there is sufficient demand to produce them at scale, causing them to be unavailable or prohibitively expensive. For example, networks of nitrogen and phosphorous sensors deployed throughout a body of water can warn officials when concentrations of these elements increase to dangerous levels as a result of polluting activities such as over fertilization, which can lead to rapid growth of toxic algae and other parasites that can poison humans and animals.[12] Such events cause $2.2 billion in damages per year, but few manufacturers have developed affordable sensors that could help officials take preventative action before pollutant levels become dangerously high. To overcome this obstacle, an initiative led by the Environmental Protection Agency called the Nutrient Sensor Challenge aims to spur the development of low-cost sensors by demonstrating the demand for affordable and effective sensors so the private sector will be encouraged to produce them at scale.[13]

As the Internet of Things is an emerging set of technologies, many of its applications may be viewed as prohibitively risky by the public and private sectors alike. As a result, risk-averse municipal governments with tight budgets will not be inclined to invest in embedding large scale sensor networks in public infrastructure or buying sensor-laden emergency response equipment. However, if no actor is willing to take this risk, the technology will not be tested effectively and go underutilized.[14] The federal government can incentivize adoption of sensors for emergency response by acting as an early adopter of these technologies or by funding pilot programs and research grants to mitigate these risks for state and municipal governments. Mitigating this risk

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[12] Joshua New, "The Internet of Things Could Stop Our Waterways from Dying," Center for Data Innovation, June 9, 2015, https://www.datainnovation.org/2015/06/the-internet-of-things-could-stop-our-waterways-from-dying/.
[13] Ibid.
[14] Joshua New and Daniel Castro, "Why Countries Need National Strategies for the Internet of Things," Center for Data Innovation, December 16, 2015, http://www2.datainnovation.org/2015-national-iot-strategies.pdf

would have the added benefit of driving additional demand, which would reduce the cost of these sensors for all parties.

Additionally, because the Internet of Things is a network technology, it is subject to the network effect, meaning its value increases in proportion to the number of users. If cities do not coordinate their deployments of sensor networks they risk developing non-interoperable systems that cannot share data with one another, limiting the potential value of analytics performed on this data and reducing the effectiveness of these systems as a whole. Conversely, emergency response agencies across multiple jurisdictions agree to adopt common standards for their deployments of sensor technology, they can all leverage more powerful analytics. Recognizing this, the European Union requires that all cars, by March 31, 2018, use a common system that can automatically notify emergency services after a crash so regardless of a driver's location in Europe, his or her car will be able to communicate with local authorities in the event of a crash.[15]

B. STANDARDS AND GUIDANCE

B1. WHAT EXISTING STANDARDS OR GUIDANCE ARE AVAILABLE WITH RESPECT TO SENSOR PERFORMANCE CHARACTERISTICS AND VALIDATION OF SENSORS?

The Department of Homeland Security's Science and Technology Directorate (S&T) is currently exploring standards for sensor technologies specifically for emergency response efforts. In March 2016, S&T completed the Incident Management Information Sharing Internet of Things Pilot project, which "investigated, developed, and tested candidate architectures, components, and relevant standards using lightweight sensors [sic]."[16] S&T will produce specifications, best practices, and demonstrations based on this pilot to support the development of sensor networks that utilize open standards.[17] Additionally, S&T launched the five year Next Generation First Responder Apex Program in January 2015 to develop and test new communications and protective technologies that can improve decision-making and reduce emergency response times.[18]

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[15] http://www.theverge.com/2015/4/29/8512845/ecall-europe-emergency-call-2018.
[16] "S&T Pilot Aimed at Improving First Responder Situational Awareness," Department of Homeland Security, Accessed March 17, 2016, https://www.dhs.gov/science-and-technology/frg-iot-pilot.
[17] Ibid.
[18] "Next Generation First Responder Apex Program," Department of Homeland Security, Accessed March 17, 2016, https://www.dhs.gov/science-and-technology/ngfr.

D. SENSORS

D7. WHAT WOULD AID THE SENSOR DEVELOPMENT COMMUNITY?

Sensor developers would benefit from public sector leadership in demonstrating the demand for this technology, as well as from public sector efforts to mitigate its perceived risks, such as by acting as an early adopter or funding pilot programs. Additionally, national-level leadership to coordinate deployments of sensor networks across jurisdictions and levels of government would substantially increase the value of these systems, thus encouraging investment. See the response to question A5 for a thorough explanation of how these actions would aid the sensor development community.

CONCLUSION:

Of the many social and economic benefits the Internet of Things can offer, improving emergency response efforts to reduce loss of life and minimize economic damage—or even avoid it entirely—is among the most important, and it is encouraging to see NIOSH working to support the development and deployment of this technology. Because the Internet of Things is an emerging technology, any rulemaking or procurement policies NIOSH develops based on these and other comments should be very forward looking to accommodate the fact that many new types of sensors, analytic techniques, and applications will emerge that could offer unforeseeable benefits for emergency responders.