REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
03-10-2017	Research	Aug - Oct 2017

4. TITLE AND SUBTITLE

Artificial Intelligence in City Planning:

Strategically Strengthening Cities in the Face of Disaster

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Lena Christine Kaman

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

USNWC, College of Naval Warfare, Newport, RI

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release. Distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Every city across the nation needs to be prepared for the possibility of a disaster. Recent disasters have highlighted one transformative key to city preparation for humanitarian assistance and disaster relief (HADR) efforts: artificial intelligence (AI) technology. With vulnerabilities from disasters so high, city officials should strengthen a city's defenses by incorporating AI technologies into planning efforts. Transportation networks, water monitors, and operations centers are three crucial areas for AI inclusion at the city level. Innovative AI technology provides a strategic tool capable of transforming existing city infrastructures into smart, prepared networks. As an added benefit, many of the AI technologies promote and encourage efficient, safe, and economical city operations for everyday life, not just for times of crisis. Officials must recognize ethical implications and keep the public's trust at the forefront of all future decisions, though, understanding that AI's value is in the thoughtful application of how it improves people's lives.

15. SUBJECT TERMS

artificial intelligence, city planning, humanitarian assistance, disaster relief, disaster preparedness, technology, innovation, homeland security, resiliency, transportation, traffic, water monitoring systems, floods, operation centers, command and control, first responders, ethics, privacy, infrastructures, strategic tool

16. SECURITY CLASSIFICATION			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a	b. ABSTRACT	c. THIS PAGE			Lena C. Kaman
	U	U	SAR	25	19b. TELEPHONE NUMBER *(Include area code)* (608)213-3397

Standard Form 298 (Rev. 8/98)

Reset

Prescribed by ANSI Std. Z39.18

Adobe Professional 7.0

Artificial Intelligence in City Planning:
Strategically Strengthening Cities in the Face of Disaster

Lena Christine Kaman

SE 539B: Innovations in Technology for Humanitarian Assistance and Disaster Relief
Research Paper
October 3, 2017

Introduction

Disasters can strike any city, at any time. While certain disasters, such as hurricanes and earthquakes, affect specific geographical areas, other types of disasters, to include fires and terrorist attacks, do not discriminate. They know no bounds, creating fissures in national security and causing harm to the public wherever they occur. Every city, big and small, across the nation needs to be prepared for the possibility of a disaster.

Recent disasters have highlighted one transformative key to city preparation for humanitarian assistance and disaster relief (HADR) efforts: artificial intelligence (AI) technology. Even though AI's inception occurred in the 1950s, some may be unfamiliar with the concept and how it has evolved.[i] Some may even be hesitant or fearful of AI-enabled computing systems, perhaps imagining a futuristic world where supercomputers dominate human beings[ii]. Stanford University's "Artificial Intelligence and Life in 2030" report offers a sound description of AI to dispel uncertainties regarding the technology. The report, authored by a panel of 17 industry experts, defines AI as "a set of computational technologies that are inspired by – but typically operate quite differently from – the ways people use their nervous systems and bodies to sense, learn, reason, and take action."[iii] For example, the speech recognition sensor on a smart device, enabling a computerized personal assistant to act and respond to a user, is a modern AI application.[iv] Further, the report explains, "AI applications will help monitor people's well-being, alert them to risks ahead, and deliver services when needed or wanted."[v] A basic familiarization of AI's scientific underpinning allows for a better understanding and grasp of a targeted use of the technology, such as in preparing a city for a disaster.

AI technology is rapidly changing the landscape of disaster preparedness and response. At the federal government level, the United States (US) Department of Homeland Security (DHS) features a robust Science and Technology (S&T) division devoted to leveraging new

technology, including AI, to improve disaster resiliency throughout communities across the country.[vi] As stated on the DHS website, "No matter the storm or manmade event, we want to empower decision makers to be ready….Preparation is key to mitigating the damage from potential disasters that threaten our nation's critical infrastructure…".[vii] By serving as a catalyst as well as a financier, DHS has set the foundation for several private sector companies to invent and introduce smart city systems to the market. With vulnerabilities from disasters so high, city officials should strengthen a city's defenses against disasters by incorporating strategic AI technologies into city planning efforts. As an added benefit, many of the AI technologies promote and encourage efficient, safe, and economical city operations for everyday life, not just for times of crisis. Transportation networks, water monitors, and operations centers are three crucial areas for AI inclusion at the city level.

Transportation Networks

A city's transportation network is one disaster-affected domain that city officials should fortify through AI technology. Transportation is one of a city's first areas to be affected prior to or immediately after the disaster begins. In the case of an impending hurricane, for instance, officials may issue an evacuation order to the citizens.[viii] Or in the case of a terrorist attack, the public will start to escape from the area as soon as they can. Traffic conditions can turn chaotic, with a city's worth of residents fleeing in their vehicles at the same time. Roads are prone to becoming jammed and traffic is likely to become bottle-necked on the evacuation routes.[ix] To illustrate, a US Department of Transportation (DoT) study titled "Effects of Catastrophic Events on Transportation System Management and Operations" reports roadway traffic flow in the Washington, DC area did not begin to return to normal conditions until 6:42 pm following the 9:43 am 9/11 attack on the Pentagon. The greater Washington area suffered from near grid-lock

conditions for nine hours.[x] If the physical condition of the city's roadways is affected, like when an earthquake destroyed four major interstate connections in Northridge, California in 1994, then the traffic situation becomes even more challenging.[xi] In either case, volatile traffic conditions put public safety at risk. The death toll from roadway mishaps reached 100 casualties during Houston's evacuation for Hurricane Rita in 2005.[xii] Residents are vulnerable to dangers such as injuries and death from vehicle crashes, heat-related illnesses from lack of vehicle air conditioning, and drowning from being trapped inside flood-swept vehicles.[xiii] Due to the immediate and crippling effects on a city and its citizens, the transportation area is a prime infrastructure for AI inclusion.

To begin, city officials should invest in an integrated system of AI sensors to alleviate disaster-related traffic challenges. An optimal AI sensing system includes radar, video cameras, remote traffic sensors, and Global Positioning Satellite (GPS) to detect vehicular traffic.[xiv] The system ties into traffic control devices such as stoplight signals, automated speed limit signs, and automated overhead highway messaging signs. When the system's sensors detect a high traffic volume, the system automatically adjusts speed limits and the timing of stoplights in order to optimize traffic flow.[xv] AI systems can also automatically load overhead highway signs with a pre-programmed message alerting drivers of contraflow, the opening of all lanes of travel in the same direction, to facilitate traffic exiting the city.[xvi] In the near future, citizens' Connected Vehicles (CV), vehicles equipped with dedicated short-range communication (DSRC) technology, will also have the capability to loop into the city's smart system to share location information and to receive traffic safety alerts.[xvii] According to the Computing Community Consortium, "AI technology can…be leveraged to move from descriptive models (data analytics) to predictive ones (machine learning) to prescriptive decisions (optimization, game theory, and

mechanism design). The potential of this transformation is being demonstrated in pilot systems that optimize the flow of traffic through cities…"[xviii] An AI-adaptive traffic sensing system serves to increase a city's preparedness by managing increased traffic flow during catastrophes.

Additionally, city officials should urge its citizens to download AI-enabled traffic applications on their smart devices. Currently, Waze, Google Maps, and MapQuest are examples of applications that incorporate AI technology. The applications combine real-time data with predictive algorithms to efficiently route traffic.[xix] As stated in an article on GCN, an information technology website, the Georgia Institute of Technology is developing a new application to ease traffic during hazardous events. The application will "send users driving directions, and if a large number of users are going to the same destination, then the app will distribute the traffic across a number of different routes, with the goal of not clogging a single urban artery."[xx] Perhaps a next step for the application can include an AI algorithm using data-sourced and crowd-sourced information on fuel and supplies availability. The application would notify users if the gas stations along their route of travel are out of fuel, for example, and re-route them on a different path if they've indicated that they need fuel. Those users that don't need fuel can remain on the route selected by the application. By promoting the use of AI-enabled applications, officials strengthen a city's defenses by allowing informed citizens to make calculated and wise travel choices.

Water Monitors

City officials should also inject AI technology into water monitoring services in order to bolster a city's defensive disaster posture. Cities near a coastline have an obvious risk of water danger from significant weather systems like hurricanes and tropical storms, but any city is vulnerable to flooding from thunderstorms or unusual amounts of rainfall. In fact, according to

the Department of Homeland Security (DHS), "Flooding is the nation's leading natural disaster, accounting for the greatest loss of life, property damage and economic impact. Over the past three decades alone, floods have accounted for $8.2 billion in damages and more than 80 fatalities per year."[xxi] Investing in low-cost flood sensors is one recommendation for city managers as a way to augment awareness of adverse water-level changes. Technologically advanced, scientific grade sensors cost between $25,000 to $50,000 a piece, however, low-cost versions are becoming prolific and relevant. At a budget-friendly $1,000 each, they add significant value to a city's situational awareness of impending water danger.[xxii] Physical Optics Corporation's (POC) low-cost design operates with a system of several nodes placed throughout the water feature. Each node contains two parts: an above-water radio unit and a submersible flood sensor. A cable connects the two pieces. The solar and battery powered nodes transmit data to city operations centers via wireless mesh digital radio signals. A third component, a gateway unit which transmits data via a more advanced Iridium satellite, is optional.[xxiii] Using the information from the systems, city officials are able to make educated and real-time decisions as to which areas need to be evacuated and which areas may require assistance. In addition to providing critical early indications to decision makers, flood sensing systems, such as POC's version, also permit first responders and emergency managers to track and access water conditions without having to put themselves in harm's way by physically traveling to survey the area.[xxiv] Arming a city's waterways with high-technology, low-cost AI sensors adds a crucial element of protection against flood vulnerabilities.

To capitalize on the proactive detection benefits of an AI-enabled flood sensing system, city officials should invest in an alert system that complements the sensors. Similar to the traffic sensor system, a city's integrated AI flood sensor system aims to not only detect imminent water

threats but also to inform the public via real-time notifications on smart devices. As an example, Progeny Systems Corporation's flood sensing architecture is an "end-to-end solution that enables alerts, warnings, and notifications to responders and citizens of ever-changing flood conditions."[xxv] Furthermore, intelligent systems allow city officials to turn real-time data into geo-targeted alerts. Through AI modeling, the system can predict which specific geographic areas of a city are likely to be affected by a flood, and city officials can send targeted evacuation notices to only that area's inhabitants instead of to the entire population.[xxvi] Eliminating all-or-nothing evacuations when possible and implementing geo-targeted evacuations saves money, prevents traffic congestion, and preserves public safety, especially in highly populated urban areas such as Houston which encompasses a population of over 2.3 million people.[xxvii] Timely and relevant notices supplement flood warning devices in defending a city and its residents against consequences of disasters.

Moreover, there is a third element available for city officials to utilize in maximizing the potential value AI flood-sensing systems provide to a city: integration with power stations. Officials should adopt flood sensing systems that are able to connect with local power stations to deliver a geo-targeted shutdown capability. The system de-energizes only those substations located in danger zones.[xxviii] In addition to targeted location services, the connected system allows for more timely power cut-offs. Based on sensor data, officials can form real-time decisions preventing de-energizing power stations too soon or too late. If stations are shutdown prematurely, citizens will be without power while they are trying to prepare for evacuation. If shutdown too late, short-circuits could cause injury, death, or irreparable damage to equipment.[xxix] Full integration of AI technology improves a city's disaster prediction and

response through a comprehensive system of water level monitors, public alerts, and power station shutdowns.

Operations Center

A final area for city officials to improve through AI technology is the city's operations center, the hub of command and control activity during HADR efforts. First of all, a city's operations center is a prime example of how AI functioning does not rest solely with computers, but how the human element integrates with smart technology. Jan Piotrowski, in his article "Artificial Intelligence to Help Disaster Aid Coordination," asserts that a combination of human and computer intellectual actions tends to be more productive, flexible, and valuable than either one by itself. The blending of human and computer intelligence into one system is termed a Human Agent Collective (HAC).[xxx] Tasks performed well by AI include collecting large amounts of data and performing subsequent complex analysis on the data set. Tasks performed well by humans include more detailed responsibilities such as analyzing the content of photos and videos and making decisions based on data. The key to successful HAC operability is to create the right balance of human and computer task division.[xxxi] To put HAC into the context of an operations center during HADR, AI-enabled software can efficiently collect and organize information before and during a disaster, such as aerial images of the scene, and then command and control officials can extract data of value to form conclusions on the way forward for the community and its population, such as issuing an evacuation order. The unified effort of HACs in operations centers facilitates an impactful defense for a city facing a catastrophe.

Overhauling conventional operations centers is a crucial step for city officials. A conventional operations center contains several workstations, each with multiple monitors and screens. The interfaces display data and video feeds gathered from a variety of sources, often

requiring a large amount of bandwidth to operate.[xxxii] AI technology can transform an antiquated conventional center into a streamlined, efficient one. Specifically, city officials should transition to a single city-wide digital platform, consisting of integrated hardware and software, that seeks to "unify all operations, data aggregation/analytics, and actions across agencies..."[xxxiii] Technology company Cisco's Smart+Connected™ City Operations Center is an example. For hardware, Cisco's product replaces the numerous workstations with a "customized and integrated, single-pane-of-glass view [for] the monitoring and control of dynamic activities involving high-resolution image processing, real-time video feeds, data integration, and various data and alert signals."[xxxiv] As for software, the digital platform connects all the city's sensor systems together, aggregates the data for display on the single layout, and integrates the sensors with a public alerting system.[xxxv] During HADR operations, command and control managers reap the benefits of real-time monitoring and synchronized data interaction. AI allows for a city's operations center to become centralized, cohesive, and up-to-the-second current, providing an efficient solution for command and control actions.

If a city cannot afford to invest in a single city-wide platform for the operations center, city officials should opt to insert AI-enabled software system upgrades where possible. For instance, the addition of damage assessment mapping software to an operations center fortifies a city's defenses when facing disastrous conditions. Based on AI algorithmic analysis of pre-loaded data such as infrastructure construction, past events, and environmental information combined with real-time disaster conditions, the software creates color-coded maps.[xxxvi] Red, for example, indicates an area that requires immediate first-responder assistance. The software solution from technology company One Concern creates the first map within 15 minutes of the disaster and then continually updates the map with new information.[xxxvii] As an added benefit,

One Concern supplements the software with a training module. A city can utilize the software to simulate an emergency to practice its operations center's response.[xxxviii] While not a comprehensive solution, damage assessment mapping software provides an operations center with one tool for disaster preparedness and response.

Privacy Concerns

Although adopting AI technology into transportation networks, water monitors, and operations centers to strengthen a city's defenses against emergencies illustrates a beneficial aspect of AI, the scientific field also presents apprehensions. Some may argue, for example, that ethical concerns over citizens' privacy need to be resolved prior to further implementation into city infrastructures. Michelle Dennedy, the Chief Privacy Officer of Cisco, defines privacy as, "the authorized processing of personally-identifiable data using fair, moral, legal, and ethical standards."[xxxix] Some may be concerned that policies are not yet in place to ensure the enforcement of privacy standards regarding data collection from AI systems. One example involves the concept of biases. Even though AI systems are designed to make unbiased decisions, the data given to the system may be biased to begin with. The AI system would not know that the dataset was biased, and could thus inform a decision that discriminates against a certain demographic.[xl] Moreover, Stanford's "Artificial Intelligence and Life in 2030" report admits while it is not likely, "that near-term AI systems will autonomously *choose* to inflict harm on people, it will be possible for people to *use* AI-based systems for harmful as well as helpful purposes."[xli] Harmful purposes include using the data collected via sensors to target individuals to generate profit. Without clear governmental guidance to regulate the new technology, public concerns over privacy issues are not unfounded.

Since AI systems do provide value to the public, city officials must balance the risks with the opportunity. Earning the public's trust is essential. To do so, it behooves the government, both at the federal and city level, to adopt transparent regulations and to enforce compliance. The federal government recognizes this challenge and addresses it in "The National Artificial Intelligence Research and Development Strategic Plan" promulgated in October 2016. The plan lists understanding and addressing ethical, legal, and societal implications as one of the key strategies moving forward and contends that "Researchers must learn how to design these systems so that their actions and decision-making are transparent and easily interpretable by humans, and thus can be examined for any bias they may contain, rather than just learning and repeating these biases."[xlii] City officials should not stop adopting AI-enabled technology, but rather should accept accountability to ensure the public is informed as to the steps that are being taken to protect privacy.

Conclusion

Disasters are often spontaneous and provide little warning as to where and when they are going to happen. Fortunately, for communities, innovative AI technology provides a strategic tool capable of transforming existing city infrastructures into smart, prepared networks. City officials should incorporate AI systems into transportation networks, water monitors, and operations centers as a crucial hedge against uncertainty from a dynamic disaster environment. In addition to bolstering a city's readiness for unexpected disasters, AI technologies also improve the core of civic life. Through optimization of day-to-day municipal activities, innovative technology allows citizens to enjoy an enhanced quality of life.

During a November 2016 Senate Committee hearing on AI, Senator Cruz noted, "Many believe that there may not be a single technology that will shape our world more in the next 50

years than artificial intelligence."[xliii] What's next for AI and city planning for HADR operations? As technology becomes more prolific and economical, city officials will be able to introduce AI technologies such as 3D printing for automated rebuilding, autonomous vehicles for automated delivery of supplies, and conversational robotics for search and recovery missions. Officials must keep the public's trust at the forefront of all future decisions, though, understanding that AI's value is in the thoughtful application of how it improves people's lives.

---

[i] National Science and Technology Council, Committee on Technology, "Preparing for the Future of Artificial Intelligence," *Executive Office of the President,* October 2016, https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf.

[ii] Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller, "Artificial Intelligence and Life in 2030, One Hundred Year Study on Artificial Intelligence," *Stanford University*, September 2016, 6, http://ai100.stanford.edu/2016-report.

[iii] Ibid, 4.

[iv] Ibid, 6.

[v] Ibid, 6.

[vi] Science and Technology, "Resilience Tactics," Department of Homeland Security, accessed October 2, 2017, https://www.dhs.gov/xlibrary/SciTechMobilizingInnovation/resilience-tactics.html.

[vii] Ibid.

[viii] "How to Prepare for a Hurricane," *Federal Emergency Management Agency,* accessed on September 26, 2017, https://www.fema.gov/media-library-data/1494007144395-b0e215ae1ba6ac1b556f084e190e5862/FEMA_2017_Hurricane_HTP_FINAL.pdf.

[ix] "Disaster Response," *Orchid*, accessed September 23, 2017, http://www.orchid.ac.uk/disaster-response-2/.

[x] Allan J. DeBlasio, Robert Brodesky, Margaret E. Zirker, and Terrance J. Regan, "Effects of Catastrophic Events on Transportation System Management and Operations," *U.S. Department of Transportation,* January 2003, 9, https://ntl.bts.gov/lib/jpodocs/repts_te/13780_files/13780.pdf.

[xi] Ibid, 33.

[xii] Aarian Marshall, "The Agony of Deciding to Evacuate a City," Wired, August 28, 2017, https://www.wired.com/story/hurricane-evacuation-houston-harvey/.

[xiii] Ibid.

[xiv] Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller, "Artificial Intelligence and Life in 2030, One Hundred Year Study on Artificial Intelligence," *Stanford University*, September 2016, 21, http://ai100.stanford.edu/2016-report.

[xv] Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie

Shah, Milind Tambe, and Astro Teller, "Artificial Intelligence and Life in 2030, One Hundred Year Study on Artificial Intelligence," Stanford University, September 2016, 22, http://ai100.stanford.edu/2016-report.

[xvi] Aarian Marshall, "The Agony of Deciding to Evacuate a City," Wired, August 28, 2017, https://www.wired.com/story/hurricane-evacuation-houston-harvey/.

[xvii] Office of the Assistant Secretary for Research and Technology, "How Does Connected Vehicle Technology Work?", *United States Department of Transportation*, accessed October 1, 2017, https://www.its.dot.gov/cv_basics/cv_basics_how.htm.

[xviii] "White House Office of Science and Technology Policy Artificial Intelligence Request for Information (OSTP AI RFI) Response," *Computing Community Consortium*, July 2016, http://cra.org/ccc/wp-content/uploads/sites/2/2016/04/CCC-AI-RFI-Reponse.pdf.

[xix] Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller. "Artificial Intelligence and Life in 2030." One Hundred Year Study on Artificial Intelligence: Report of the 2015-2016 Study Panel, Stanford University, Stanford, CA, September 2016, 22, http://ai100.stanford.edu/2016-report.

[xx] Matt Leonard, "Atlanta and Georgia Tech Roll Out Smart City Projects," *gcn.com*, September 18, 2017, https://gcn.com/articles/2017/09/18/atlanta-smart-city.aspx?admgarea=TC_STATELOCAL.

[xxi] Science and Technology Directorate, "Internet of Things (IoT): Low-Cost Flood Inundation Sensors," Department of Homeland Security, March 22, 2107, https://www.dhs.gov/sites/default/files/publications/Flood-Sensor-Fact-Sheet-170322-508.pdf.

[xxii] Stephanie Kanowitz, "Can IoT Protect Communities When the Next Floods Come?", *gcn.com*, September 20, 2017, https://gcn.com/articles/2017/09/20/iot-flood-sensors.aspx?admgarea=TC_STATELOCAL.

[xxiii] Science and Technology Directorate, "Internet of Things (IoT): Low-Cost Flood Inundation Sensors," Department of Homeland Security, March 22, 2107, https://www.dhs.gov/sites/default/files/publications/Flood-Sensor-Fact-Sheet-170322-508.pdf.

[xxiv] Public Affairs, "S&T Uses Internet of Things to Improve Flood Alert Technology," *U.S. Department of Homeland Security,* July 26, 2017 (10:03 a.m.), https://www.dhs.gov/blog/2017/07/26/st-uses-internet-things-improve-flood-alert-technology.

[xxv] Ibid.

[xxvi] Stephanie Kanowitz, "Can IoT Protect Communities When the Next Floods Come?", *gcn.com*, September 20, 2017, https://gcn.com/articles/2017/09/20/iot-flood-sensors.aspx?admgarea=TC_STATELOCAL.

[xxvii] Ibid.

[xxviii] Ibid.

[xxix] Ibid.

[xxx] Jan Piotrowski, "Artificial Intelligence to Help Disaster Aid Coordination," *SciDevNet*, December 27, 2013, http://www.scidev.net/global/disasters/news/artificial-intelligence-to-help-disaster-aid-coordination.html

[xxxi] Ibid.

[xxxii] "Smart+Connected Operations Center," *Cisco*, accessed October 2, 2017, https://www.cisco.com/c/en/us/solutions/industries/smart-connected-communities/city-operations-center.html.

[xxxiii] Kenn Dodson, "Top 5 Smart City Predictions: AI and the Birth of Self-Aware Cities," *Cisco*, August 1, 2017, https://blogs.cisco.com/government/top-5-smart-city-predictions-ai-and-the-birth-of-self-aware-cities.

[xxxiv] "Cisco Smart+Connected City Operations Center: Unified Management for City Infrastructure," *Cisco*, accessed October 3, 2017, https://www.cisco.com/c/dam/en_us/solutions/industries/docs/scc/scc-city-operations-center-aag.pdf.

[xxxv] Kenn Dodson, "Top 5 Smart City Predictions: AI and the Birth of Self-Aware Cities," *Cisco*, August 1, 2017, https://blogs.cisco.com/government/top-5-smart-city-predictions-ai-and-the-birth-of-self-aware-cities.

[xxxvi] Dave Boyce, "How Artificial Intelligence May Help When Disaster Strikes," *The Almanac*, September 28, 2017, https://www.almanacnews.com/news/2017/09/28/cover-story-when-disaster-strikes.

[xxxvii] Ibid.

[xxxviii] Ibid.

[xxxix] Michelle Dennedy, interview by Michael Krigsman, *CXO TALK*, Episode 229, April 28, 2017, https://www.cxotalk.com/episode/artificial-intelligence-privacy-engineering.

[xl] Peter Stone, Rodney Brooks, Erik Brynjolfsson, Ryan Calo, Oren Etzioni, Greg Hager, Julia Hirschberg, Shivaram Kalyanakrishnan, Ece Kamar, Sarit Kraus, Kevin Leyton-Brown, David Parkes, William Press, AnnaLee Saxenian, Julie Shah, Milind Tambe, and Astro Teller, "Artificial Intelligence and Life in 2030, One Hundred Year Study on Artificial Intelligence," Stanford University, September 2016, 10, http://ai100.stanford.edu/2016-report.
[xli] Ibid.
[xlii] National Science and Technology Council, Networking and Information Technology Research and Development Subcommitte, "The National Artificial Intelligence Research and Development Strategic Plan," *Executive Office of the President,* October 2016, 26, https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/national_ai_rd_strategic_plan.pdf.
[xliii] Hearing, "The Dawn of Artificial Intelligence," *U.S. Senate Committee on Commerce, Science, and Transportation,* November 30, 2016, https://www.commerce.senate.gov/public/index.cfm/hearings?ID=042DC718-9250-44C0-9BFE-E0371AFAEBAB.