Technology Roadmap for Hawaii Resiliency

Resiliency and Sustainability through Advanced Analytics

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Abstract*—The state of Hawaii faces numerous challenges that threaten its survival. Tsunamis, weather-induced mud-slides, and global climate change impacts are just a few of the threats that could cripple Hawaii. The state is increasingly vulnerable because of aging infrastructure and the fact that its economy is highly dependent on tourism and construction, military, or government projects. To improve Hawaii's resilience, this effort proposes steps that will enable analytics based decision support to combat the major threats. In this paper, we describe a technology roadmap that will guide Hawaii to pioneer a sound resiliency approach, facilitate implementation of a resiliency plan, develop the required resiliency technologies, deploy the resiliency technology and improve Hawaii's infrastructure, and foster growth of a technology-based resiliency industry that will sustain Hawaii's resilience. As a successful pathfinder for resiliency, Hawaii will be positioned to lead the way for many other cities, states, nations, and even regions of the world that face similar threats. ***Keywords—resiliency; sustainability; technology roadmap; analytics; decision support; high performance computing; hyper-local weather forecasting.***

I. INTRODUCTION

In industry, the concept of formulating a technology roadmap in order to envision the future, articulating a desired end-state, and developing a plan of action to reach that end-state is valuable to align the key players and motivate them to mobilize their resources towards a common goal. The technology roadmap provides a valuable mechanism for communication between all parties involved and enables key decisions, such as standards, and other required preparations, to take place in advance of arriving at the end-state goals. Since none of the key players in this Hawaiian resiliency initiative possess sufficient resources to execute the plan individually, a Public Private Partnership Initiative (P3I) is the best mechanism to achieve this goal. In this paper, we will show how we adapted the technology roadmap concept, borrowed from industry, formed a public private partnership aimed to achieve Hawaiian resiliency, and developed the roadmap details.

The central element of the technology roadmap is the vision or desired end-state. As hinted in the previous paragraph, the end-state for this roadmap targets improvements in Hawaii resiliency. However, the future envisioned for Hawaii is even greater, proposing that Federal, State, and local authorities team with academic and industrial partners to construct and implement a plan that will position Hawaii to be a pathfinder and world leader in developing resiliency technologies. The motivation for this ambitious end-state is to counter serious threats that pose grave danger to Hawaii's very survival.

Hawaii faces several major, imminent threats. The first threat is an impending economic downturn that will be compounded by dependence upon a tourism-heavy economy [1]. The second threat is the weather and environment [9] [10] [11]. These threats are deeply compounded by Hawaii's isolated location and aging infrastructure. The third threat is the emerging cyber-threat that is shared by the entire globe and could cripple Hawaii's economy even if steps are taken to avert the predicted economic downturn and could be wielded by an adversarial actor(s) to intentionally attack elements of Hawaii's economy or difficult-to-defend critical/strategic infrastructure, or to hamper Hawaii's emergency response mechanisms.

It is important to note that these threats are linked. Achieving resiliency requires a stable economy, and a stable economy requires resiliency. Conversely, the coupling magnifies the potential impact of any of these threats and poses severe challenges to Hawaii's resiliency. In a sense, the combined threats facing Hawaii represent the “perfect storm” that is looming in the not-too-distant future, darkening the horizon. To make matters worse, there seems to be universal agreement that Hawaii is under-prepared to meet these challenges should they should solidify and that should any of the threats materialize, it would exact a terrible toll.

To fully understand the Hawaiian resiliency vision and technology roadmap end-state, it is necessary to describe each major threat in detail. Section II will endeavor to do so. Section III will present the technical solutions required to counter the threats facing Hawaii and repair its vulnerabilities. This section will present a technology roadmap that implements the required solutions as part of a comprehensive approach to develop a new resiliency industry that will sustain and extend Hawaii into the future. Section IV will present the status and progress towards achieving Hawaiian resilience, Section V will describe the technology roadmap, and Section VI will detail future steps that remain to be executed. Finally, the summary section will highlight the main points of the

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document and present reasons why the successful implementation of this technology roadmap is of strategic importance to the U.S. and the rest of the world.

II. DETAILED CHALLENGES

A. *Environmental Challenges*

The Hawaiian islands are the most isolated chain of islands in the world, located in the middle of the Pacific Ocean and quite exposed to the impacts of mother nature. As such, Hawaii faces tremendous challenges due to hostile weather and environmental phenomena like hurricanes, tsunamis, storms and related flooding, volcanic eruptions and lava flows, mud slides, global climate change, and more.

The danger posed by a tsunami is well-known and widely feared. On March 11, 2011, the Tohoku earthquake triggered a tsunami that inundated the Fukushima Nuclear Power Plant on the coast of Japan and resulted in the Fukushima Daiichi nuclear disaster when 3 of the 6 nuclear reactors melted down. While most of the direct damage of a major tsunami cannot be averted, certain measures to prepare can indeed reduce some of the secondary impacts, if there is sufficient warning. Often a major storm or tsunami will take down the power grid. In fact, the power grid can be shut down intentionally in anticipation of an impending tsunami. Pumping stations for water distribution and waste water sewage can be prepared with extra fuel for backup generators to allow water pumping to continue when it is most necessary, particularly with the proviso that there is sufficient warning to do so. With regards to the tsunami warning buoys placed in the Pacific to warn Hawaii of impending tsunami, the National Research Council of the National Academies have called for a replacement strategy. Furthermore, the antiquated technology on the buoys are more of a liability to Hawaii than as the intended functionality of a safety mechanism, for the buoys have no robust protection mechanism to defend against hackers attempting buoy spoofing as well as other adverse actors that could trigger a warning and induce decision-makers to shut down the power grid in Hawaii.

Hawaii struggles to produce sufficient, affordable, and stable power. Outages occur due to demand combined with infrastructural issues, vegetation overgrowth, and other phenomenon affect the islands. Such interruptions incur economic penalties, but also can have deadly consequences when emergency equipment ceases to run, pumping stations fail, and similar shutdowns occur. Not only from the result of severe weather events, on a daily level, Hawaii faces a continuous occurrence of adverse micro-weather affects that may have causal impacts. While Hawaii has enthusiastically adopted solar technologies to leverage its tropical sunshine to produce energy, unanticipated micro-changes in cloud cover can profoundly affect matters. As a result, the switching points between solar and fossil-fuel based electricity production can indeed be better optimized so as to cope with these micro-weather changes.

As a longer-term threat, global climate change threatens to elevate sea level and the consequences could be dire for Hawaii. In Hawaii, a rising sea level could lead to increased soil salinity levels in coastal areas along the perimeter of all the islands. This change in soil chemistry could potentially force insects, such as termites to higher grounds, thereby impacting telephone poles and similar infrastructures that were previously not as vulnerable.

B. *Economic Challenges*

Economic challenges are not usually direct threats to existence, but in the case of Hawaii, economic issues elevate Hawaii's vulnerability and compound the impact of the environmental threats. Upgrades to aging infrastructure so as to counter the threats require a significant amount of funds. Sustainment of the upgraded infrastructure will require long-term economic stability. Along this vein, longer-term economic stability depends upon a broad-based economy supported by more than just tourism and the construction, military, and government projects that have traditionally boosted Hawaii's economy. Thus, in order to achieve sustained resiliency, Hawaii needs to foster new technology-based drivers for its economic growth that will allow it to compete favorably in the increasingly global marketplace even when its traditional sources of funds are less available.

Due to its geographical location, Hawaii is the most isolated island state in the world. As such, it has always faced steep economic challenges. For one, any enterprise in Hawaii, whether individual, commercial, or government, raw materials and energy cost significantly more. Solar energy may offset some of the additional cost of energy, but as of yet (despite its enormous potential), it does not make up the difference. Electricity can cost 3-4 times the price it does on the mainland. Furthermore, climate change and global warming impacts will place more drag on the economy by forcing Hawaii to respond to the changing conditions to well protect its infrastructure. By depending upon tourism and construction, military, and government projects to drive the economy for many years, Hawaii has not kept pace with the increasingly global and competitive marketplace. Thus, Hawaii's economy is highly vulnerable and dependent on numerous factors beyond its control.

Many of the aforementioned disadvantages described above already disfavor industry investment in Hawaii and lead new companies to take root elsewhere than in Hawaii. However, there is yet another far more significant factor that threatens to drive away future business opportunities. Hawaii lags in certain critical/strategic infrastructure to support the burgeoning Internet bandwidth need that is crucial to the modern global marketplace, and its current trans-oceanic cables faces physical degradation by traditional end-of-life factors. Streaming video can be problematic because bandwidth is so limited, which means that tele-meeting technologies, such as video teleconferencing (VTC), educational opportunities for remote learning, and many other high-bandwidth data streaming applications may be impacted.

Model predictions indicate that Hawaii will face an extended economic downturn in less than 5 years, if no measures are taken. In order to minimize impacts of the downturn and, conversely, actually drive the economy, it is imperative to incorporate new growth factors that will broaden Hawaii's economy beyond its current pillars of tourism, construction, military, and government. In particular, to compete in the increasingly competitive and global market place, it is vital that Hawaii rejuvenate its economic engine by both attracting and starting technology innovation. One means

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to accomplish this crucial revitalization of the economy is for Hawaii to boldly address its resiliency problems by developing innovative and comprehensive solutions, fostering a novel resiliency industry, and committing education and training resources to train others. In doing so, Hawaii would become a world leader in resiliency, and serve as a resource from which others can learn. Due to its unique property as being the most isolated island chain in the world, Hawaii is, in essence, a bounded problem set and is an ideal "living lab" for industry.

III. APPROACH TO OVERCOME CHALLENGES

Hawaii does have several resources and advantages that it can leverage to overcome the challenges threatening its future. For one, Hawaii is a relatively closed system that makes it easier to attack the resiliency problem from a comprehensive perspective. Second of all, Hawaii is still on solid economic footing, so there are economic resources to utilize in improving its resilience posture. Additionally, Maui still is the home of the Maui High Performance Computing Center (MHPCC), which greatly enhances Hawaii's ability to build up the sophisticated analytic-based decision support aids that are required to implement a smart-grid, smart-buoy defense system, and —ultimately — smart-cities.

To counter the dangers outlined in the previous section, a number of inter-related improvement efforts must be initiated. First, the tsunami-warning buoy system must be upgraded. According to the 2010 Report "An Assessment of the U.S. Tsunami Program and the Nation's Preparedness Efforts," by the National Research Council of the National Academies, the current system, known as the Deep-ocean Assessment and Reporting of Tsunamis (DART), which services the U.S. (and Hawaii) as well as 50 other countries, is unreliable. For example, "of the 39 stations deployed in 2008 only an estimated 60 percent were operational by 2009." New sensors and security must be incorporated into the buoys to truly improve the tsunami defense, improve Hawaii's defensive posture, and reduce security risks. These buoys sensors will collect data that will have to be transmitted to a central location for analysis and decision support. One proposed solution is to utilize Unmanned Aerial Vehicle (UAV) communications to create a network that ultimately connects the buoys to the MHPCC, perhaps in conjunction with satellites. Second, the broadband initiative is critical to replace existing broadband before it reaches saturation and/or physically degrades. Interruption in Internet capabilities would expose Hawaii's security and economy to grave risks. Furthermore, due to the time required for such an upgrade, the time to act on this upgrade is quite limited. Third, Hawaii's grid and other infrastructure must be instrumented appropriately to enable smart-grid and smart-city capabilities. Finally, many of the new sensors must be connected, ultimately, to the Maui High Performance Computing Center, so as to enable analytic engines to derive insights from the raw data, and edge analytic systems must be deployed in those situations where such connection is not feasible.

To process the live data streams, the MHPCC will be equipped with advanced software systems that comprise a crucial component of a modeling and analytics infrastructure that is aiming to achieve lasting resilience for the State of Hawaii. These computational capabilities will be both enabled and sustained by increased bandwidth resulting from new data channels provided by the Hawaii Broadband Initiative. To support resilience, this data analytics architecture will support connections to a variety of data streams, including data from sensors from a future smart-grid utility infrastructure, the future replacement sensor buoys for the aging storm-warning/tsunami-detection buoys, processing satellite imagery from the existing Earth Observation System, sensor data from existing and future weather balloons, and potentially many other sources.

To enhance Hawaiian resilience, MHPCC high performance computing systems will host software algorithms that are designed to accept real-time data streams, analyze the data within a suitable historical context by leveraging available meta data, automatically detect patterns from which insights may be derived, infer relationships from interconnections between data elements, and provide advanced decision-making tools that will help local, state, and federal leaders to protect Hawaii's electrical grid, provide hyper-local weather prediction in addition to alarm for storms, tsunamis, mud slides, and other adverse environmental events. These same analytic tools can, ultimately, be harnessed to empower a growing technology based economy.

Initially, the most critical of the myriad of challenges to tackle seems to revolve around the weather challenges. This sub-challenge benefits from the fact that the technical approach, computing approach, and sensors already exist. The IBM Deep Thunder system offers technology that has been developed to provide local, high-resolution weather predictions customized to weather-sensitive specific operations. For example, it could be used to predict situations ranging from flooding and/or damaged power lines to anticipating cloud cover over the Hawaiian island of Maui.

IV. STATUS AND PROGRESS OF RESILIENCE INITIATIVE

There has been significant progress related to the resiliency initiative. As a Public Private Partnership Initiative (P3I), the resiliency initiative is a combined effort among the State of Hawaii, U.S. Pacific Command (PACOM), Swansea University's Network Science Research Center, IBM Smarter Cities and Safer Planet, Mehta Tech, Synerscope, and others. On July 7, 2014, State of Hawaii Senate Bill 2742 (Act 229) — co-sponsored by then Senator David Ige (now Governor for the State of Hawaii) — was signed into law by then Governor Neil Abercrombie. The 28th Legislature of the State of Hawaii is currently working on legislation related to the Pacific-Asia Institute for Resiliency and Sustainability (AIRS) mission, including explorations for a new trans-oceanic broadband connection. In addition, PACOM co-sponsored a Resiliency Symposium in Honolulu, Hawaii, which featured presentations by the Sensemaking-PACOM Fellowship.

V. TECHNOLOGY ROADMAP

Outlining the process to develop a technology roadmap is itself an important element of achieving success. In this paper, we adapt the steps defined in [3] from the industry context to the Hawaii Resiliency problem space. First, it is important to ensure that developing a technology roadmap will actually yield benefits to the parties involved. After all, we have already identified strong candidate solutions to the problems that threaten Hawaii's future. Do we really need a resiliency technology roadmap? In this case, the motivation for developing a technology roadmap is two-fold. From a resiliency perspective, while potential solutions have been identified to many of the threats described earlier, some of the technologies have not been fully developed to achieve the sustained resiliency that Hawaii aims to achieve. For example, cyber-technology seems to lack the required level of maturity. Therefore, to achieve Hawaii's resiliency vision, it will be essential to develop a new resiliency technology base. As such, the technology roadmap will be of great value to outline the steps to achieve this. Additionally, the logic is similar from a sustainment point of view that in order to maintain the fledgling resiliency technology industry, which will provide the necessary latent stability, it will actually be advantageous to grow much of the resiliency technology locally. This will effectuate a sustained econometric framework that will serve as a sustained driver to Hawaii's economy and will help insulate Hawaii's isolated islands from the uncertainties inherent in the historical principal economic dependence on tourism, construction, government, and military projects.

Once the benefit of a technology roadmap is established, it is important to select champions that have the know-how, resources, and leadership to bring about the benefits envisioned by the roadmap. In order to achieve Hawaiian Resiliency, the optimal choice is a Public-Private Partnership Initiative, involving the state of Hawaii, local leaders, PACOM, MHPCC, AIRS, the Sensemaking Fellowship, several academic institutions, and several industry partners. None of these parties alone have the resources to effectuate the desired outcome, but together in partnership, many of the foundational pieces that will be required by the resiliency technology roadmap are already being put in place. To enact this resiliency vision for Hawaii, critical resource elements are required, which include political capital, funding, computational resources, subject matter expertise, academic support, and a strong network of relationships with potential candidate technology partners, some of which might help realize the vision. Many of these elements are provided by the P3I members, some of whom are referenced in the February 7, 2014 and October 31, 2014 Hawaii Department of Defense press releases regarding their participation with PACOM and others on methods to improve energy efficiency and grid operations. The process that will be used to develop the technology roadmap has already started. This may seem counter-intuitive, but the vision of the technology roadmap described above represents a sustained resilience approach that is clearly a super set of the solutions developed to mitigate the immediate threats posed by an aging tsunami-warning system, aging infrastructure, looming global climate change effects, and broadband end-of-life. Thus, essentially, the resilience initiative has evolved to achieve a sustainable solution that involves growth of an entire industry.

The process has included a hybrid expert and local workforce-based approach. PACOM co-hosted a Hawaii resilience symposium organized in a workshop setting that highlighted a fairly comprehensive resilience approach. The Senate Majority Leader discussed legislative progress related to various elements of the resiliency initiative. Subject matter experts from the Sensemaking Fellowship and AIRS discussed aspects of the resilience approach with audience members which included officials, legislators, and department members from the state of Hawaii, local officials, representatives of the MHPCC, academic leaders, and other interested parties. Subsequently, the Sensemaking Fellows met individually with representatives of many of these groups to explain technical components, highlight requirements of the overall approach, and solidify the crucial elements of the technology roadmap.

As discussed before, this technology roadmap has been developed to achieve sustained resilience, evolving far beyond simple mitigation of several of the immediate threats, so as to help position Hawaii as a leader at the forefront of resilience technologies and to demonstrate this leadership by example, such that the rest of the world will look to Hawaii for resilience solutions. The components of the roadmap were adapted from [3] and [4] to fit within the P3I approach. The technical roadmap in [3] included 5 major components: “Goals”, “Milestones”, “Gaps and Barriers”, “Action Items”, and “Priorities and Timelines.” The elements of the technology roadmap presented in [4] were greater in number and more specific and focused on long-term benefits from primarily an industry point of view. The technology roadmap presented here differs from [3] and [4] because it has both a primary goal of solving the Hawaiian resilience challenges and a secondary goal of positioning Hawaii — for sustained resilience — as the leader in resilience by fostering a local technology industry and building local training programs, both academic and otherwise, related to resilience technologies.

The first section of the technology roadmap is an analysis of the specific challenges facing Hawaii, a summary of existing technologies available to counter those challenges, aspects of the threats for which no solution exists that will require research and innovation to overcome, and an evaluation of resilience technologies and industry trends. The threats facing Hawaii were discussed in section II and solutions to overcome those challenges were presented in section III. These aforementioned threats do not fully describe or address the hurdles that exist for Hawaii to attract technology companies; there are fairly generous tax credits for companies to locate in Hawaii, but there are severe disadvantages as well. Businesses seeking to locate within Hawaii face difficulties ranging from its geographical remoteness to its relatively high energy costs (more expensive than the mainland for electricity) high cost of living, high cost for businesses, challenge of recruiting, and a limited venue for venture capital. In light of these obstacles for an individual company, the goal of growing an entire new technology industry in Hawaii represents a steep hill to climb.

In the next step, it is important to determine resilience technology and expertise focus areas in which Hawaii already has an edge or that a potential budding Hawaiian resilience industry could excel and also directly support Hawaii's resilience needs.

In this case, the Hawaii island of Maui already hosts one of 5 DoD super computing sites, the Maui High Performance Computing Center (MHPCC). The MHPCC supercomputers already host numerous tools for computational modeling, many of which can be of great value for design of new systems, enabling rapid prototyping and significant savings. New network science and analytic tools can be added [6] atop hyper-local forecasting capabilities, such as Deep Thunder. Deep Thunder is a research project by IBM, being offered in this instance by the IBM Center for Resiliency and Sustainability, which aims to improve short-term local weather forecasting through the use of high-performance computing. It is part of IBM's Deep Computing initiative that also produced the Deep Blue chess computer. Deep Thunder is intended to provide local, high-resolution weather predictions customized to weather-sensitive specific operations. For example, it could be used to predict situations ranging from the wind velocity at an Olympic diving platform to flooding and/or damaged power lines. Additionally, the Sensemaking Fellowship provides expertise in numerous science and technical areas that will directly support these efforts. For example, members of the Sensemaking Fellowship already have experience running complex computational electromagnetic modeling simulations [5] on high performance computer systems similar to the MHPCC, conducting information theory and network science [2] research highly relevant to the analytic systems that will be required for the resiliency initiative, and currently study many of the topics that are directly relevant to the resilience initiative. Another participant, Hawaii Pacific University intends to start a Resilience Masters program for future Sensemaking Fellows in conjunction with Swansea University. These kinds of shifts resulting from initiating a resiliency industry could stimulate significant growth and improvement in the quality of the overall high technology workforce and related educational institutions.

The threats facing Hawaii and solutions to those threats were described earlier, but it is also important to describe the principal obstacles that will hamper both the Resilience initiative and a potential new resilience technology industry in Hawaii. Primary of these, are inertia effects, such as political inertia, the fact that currently Hawaii has no technology industry to speak of, disadvantages posed by the high cost of materials, energy and operating budget, a lack of top quality technical talent currently existing on the islands, and high costs of the its isolation. For those that live in Hawaii, paying significantly more for gas, milk, bread, housing, and many other daily needs are only part of the penalty for living in paradise. The aforementioned financial penalty is compounded by other related impacts of Hawaii's isolation. Technology companies are reluctant to translocate themselves to the isolated environment, which has a ripple effect. The lack of technology industry translates to a technical workforce with fewer graduate degrees in technical topics. The result of this shortage equates to a decreased number of highly skilled engineers, scientists, and mathematicians to sustain a high quality education system related to any of these topics. This problem is self-reinforcing because families of highly skilled technologists are less likely to choose to raise children in a weaker academic setting.

It is important to identify crucial steps of the plan that imperil the entire initiative if these elements fail. For the Hawaii resilience initiative, showstopper failure steps include passage of pertinent legislation, critical tsunami-warning buoy replacements/upgrades and related UAV support to transmit data to analysis centers, the smart grid upgrade, deployment of the hyper-local forecasting analytic engine, execution of the full scope of the broadband initiative, and assimilation of critical cybersecurity measures. For any plan, it is helpful to employ success metrics to evaluate progress. The initial performance metrics for the resilience initiative are mostly discrete in nature. These include, successful passage of the legislative elements, validation tests for the smart grid, validation tests for the hyper-local weather forecasting, demonstrations and validation tests for the tsunami-warning buoy system, a tangible and sizeable increase in the number of technology companies initiating business in Hawaii to support the resiliency initiative as well as related training companies, a significant increase in the number of students completing the resiliency academic programs, significant level of commerical leasing of the new broadband fibers, and measures that assess the cybersecurity posture of Hawaii. So, it is crucial that this stage of the initiative produce the measures described above.

To achieve sustained resilience, it is important to develop a plan to build and foster the industry, maximize commercialization of resulting technologies, advertise the resulting new technologies, training programs, and expertise, and to acquire or otherwise build and grow the budding industry. This is already the approach that is underway. The state, AIRS, and PACOM have used numerous open forums to advertise the initiative broadly and provide training, including multiple Resiliency and Sustainment Symposiums, conferences, workshops, and meetings. Table 1 lists numerous of these activities and events.

Table 1: Sustainment and Resiliency Outreach Activities

Date Range	Venue
06/22/14 to 06/25/14	Naval Postgraduate School's Cyber Endeavour/Cyber X-Games in Monterey, CA
09/09/14 to 09/10/14	IBM i2 Summit in Washington DC
09/29/14 to 10/03/14	TAG Summit in San Diego, CA
07/23/14 to 07/27/14	Aspen Security Forum in Aspen, CO
10/14/14 to 10/16/14	The 4th National Conference on Building Resilience through Public-Private Partnerships in Washington DC

Of note, the TAG's attendance in Cyber Endeavour/Cyber X-Games at the Naval Postgraduate School resulted in a mutually beneficial exchange with the CIP practitioners from the mainland. Parties from the State of Hawaii and the mainland acknowledged ongoing vulnerabilities, such as the San Jose attack on critical infrastructure as well as the Chicago Aurora Radar Center fire, which devolved operations to other airports. Unanticipated issues were discussed, such as those delineated in the recent publication, "Milk or Wine: Are Critical Infrastructure Protection Architectures Improving with Age?" Additionally, the TAG Summit utilized a Hawaii-centric approach, and the outlined engineering pathway is consistent with the spirit of DOD High Performance Computing Modernization Program (HPCMP) and the aforementioned EOs and PPDs.

Finally, this section of the strategic roadmap describes the Public Private Partnership Initiative that has been assembled for the resilience initiative and outlines roles for the various participants. Excerpts of this can be found on the Hawaii DOD websites [7] [8].

These documents outline the Public-Private Partnership for the Resiliency and Sustainment Initiative.

VI. CONCLUSION

This paper has presented a technology roadmap that outlines the path to achieve Resilience and Sustainability for Hawaii. This technology roadmap is a key element of the resiliency and sustainment initiative, which will lead development of these industries.

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