Maine EPSCoR FY19-24 NSF EPSCoR RII Track-1
Proposal Development Process Phase I – Research Concept Paper (REVISED 3/22/17)

1) Proposed Research Focus:	Broadband Wireless Access and Secure Sensing (BWISSE) with applications in Natural and Human Resources Monitoring				
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4) Intellectual Merit: (the research focus)

A. ***Need*: NSF Press Release (16-085) *"nearly 350 million smartphones, connected tablets and wearable devices in use -- more than double the number from a decade ago -- carrying more than 100,000 times the traffic they supported in 2008."*** In this day and age, Broadband Wireless Access and Secure Sensing (BWISSE) is a critical need for a vibrant and globally competitive economy. A recent report published by Maine Forest Economy Growth Initiative titled: Recommendations to Strengthen and Diversify Maine's Forest Industry and Rural Economies states that *"Affordable, reliable, and high-speed broadband access is a prerequisite for any business in the 21st century."*. Moving from text-based internet and email communications to multimedia video-rich environments, the demand for high-speed broadband with low latency has been exponentially growing in the past decade. Maine's economy heavily relies on tourism, forestry, aquaculture and marine industries and a large number of small businesses, all in urgent need of higher broadband speeds at lower costs and larger number of sensors and data collection devices. The fiber optic backbone is already in place. It is time to take advantage of the existing infrastructure and connect the last mile using new wireless technology that needs to be researched and developed for sparsely populated Maine with its challenging hilly and forested terrain with a long coast line. This NSF investment positions Maine to become a national leader in rural broadband by creating a public-private partnership.

B. ***Research Goal & Objectives:***

The current trend in wireless research is motivated by high demand in dense urban areas, with minimal to no attention to sparsely populated rural areas. In addition to day to day activities that require broadband access, secure sensor networks can use the idle spectrum to monitor forests for changes in CO2 levels, detect wildfires early, assist in securing borders, and even enable vehicle to infrastructure communication to prevent accidents. Integration of these two technologies, namely access and sensing in a secure manner is the key aspect of the proposed low cost network. The main goal of the proposed research in this concept paper is to develop new paradigms for expanding wireless access in sparsely populated rural areas with challenging (non-flat terrain) environments. Hilly terrain, year-round forest foliage changes, and extreme temperature variations combined with snow and highly humid summers, makes Maine the most challenging environment for creating a reliable broadband wireless. The proposed research objectives to address these challenges are:

a. Radiowave propagation research for rural environments and close to ground antennas
b. Wireless access systems in support of tourism, border/port security and aging populations
c. Wireless sensor networks in support of natural resources monitoring (Forestry, agriculture, aquaculture)

C. ***Research Actions:***

Research action-1 (supports obj. a, b): research activities leading to development of radiowave propagation models for forested areas verified by experimental measurements and refined in several iterations.

Research action-2 (supports obj. b, c): research and development activities on devices that can withstand extreme environments while providing consistent performance over a large bandwidth.

Research action-3 (supports obj. a, b, c): research on network security and scalability as number of users and demand is increased, and developing a new framework to integrate wireless access and sensing into one secure network.

Research action-4 (supports obj. a, b, c): research on computational algorithm suitable for distributed and decentralized implementation to reduce the communication needs and eliminate the requirements for a central processing facility.

Research action-5 (supports obj. a, c): collaborating with forestry and aging initiative researchers and industry end-users to determine projected bandwidth requirements for sensor networks and developing new models for near ground radios indoors and outdoors.

D. ***Priority:*** On **July 15, 2016**, the National Science Foundation (NSF) announced that it will invest more than **$400 million** over the next seven years to support fundamental wireless research and to develop platforms for advanced wireless research. "On **March 9, 2017** NSF announced a new program called the Platform for Advanced Wireless Research to build wireless-technology research hubs across the country, backed by nearly **$100 million in pledged funding** and resources. This initiative will bridge relationships between cities, tech companies and academia so they can develop technologies like 5G wireless networks, fiber backhaul, advanced networking systems and Internet of Things applications."

The proposed research in this concept paper integrates emerging concepts such as cooperative communication, cognitive radio, secure sensor networks, vehicular networks, and advanced propagation models to address the challenge of delivering wireless connectivity to sparse populations in large cells. This is in contrast with the current move toward small cells in densely populated urban areas. The strong aspect of this proposal is in its proposed cohesive activities with end-users and domain researchers helping

to steer the research in a relevant and practical manner.

5) Broader Impacts: (related to the research focus)

E. ***Societal Impacts****:* Global competitiveness for various Maine industries, including forestry, agriculture, fisheries, millwork, and healthcare heavily relies on availability of broadband access for marketing, getting orders, and efficient use of sensors for monitoring patients in homes or older individuals in retirement homes. Several examples of such needs have been documented when the proposal team met with local industry in the past few years, several funded research pilots were completed, and preliminary data was collected.

F. ***Economic Impacts****:* Economic development resulted from investment in broadband wireless and sensing is two fold. First, enhancing the operation of existing businesses by boosting their connectivity at low cost. Second, attracting new businesses to Maine and job creation can fundamentally change the state's economic landscape. Total economic impact of forest products industry in 2016 is estimated at $8.5 Billion while supporting 33,538 jobs in Maine. According to a recent report by the State's ConnectME Authority, economic impact of Broadband on the Maine economy over the coming decade would be to add 11,000 jobs, create $500 million in new income, and pass along $70 million new dollars a year to state and local governments. Two examples that can illustrate the impact of the BWISSE project includes assisted living in smart homes for aging population and creation of infrastructure sensors for driverless cars that can actually operate safely in snow covered roads. The resulted savings in healthcare costs for the state and the number of jobs created for design and maintenance of these devices in future will be huge.

G. ***Workforce Development****:* This EPSCoR proposal will attract top graduate students, postdocs and faculty to Maine noting the unique physical infrastructure investment in this area and availability of statewide test-bed for novel research in forestry, oceanography, aging, and transportation. Undergraduate students trained in this area will be feeding the workforce pipeline, while getting trained at UMaine and via participating in industry internship programs. Mentoring programs and focusing on a diversified workforce are some of the objectives of our proposed workforce development efforts.

H. ***Infrastructure Building****:* It is critical to note that the existing physical infrastructure at UMaine funded by MTI (Maine Center for Next Generation Wireless Communications $2.2M including 4 labs), local industry (WiSe-Net and VEMI Labs), and federal grants (Wireless Sensing Lab, Advanced Computing Group), need to be augmented by investing in human resources (new faculty, technicians, research admins and staff). In other words, UMaine is well-positioned to attract highly qualified researchers in the wireless broadband and sensing area and can quickly produce new technologies with commercial value (this has been proven in small scale on shoestring budget with great potential to scale up). This project brings together researchers from UMaine Signature/Emerging areas in Engineering, Data Science, and Forestry.