PAWR Preliminary Proposal.

Project Title: Advanced Wireless Application Research Environment (AWARE)

Lead Institution: Texas A&M University

Vision and Technical Merit

Primary Application Use Cases

Public Safety – 5G and other advanced wireless research in the public safety vertical has the potential to revolutionize the way that first responders protect our citizens. The AWARE platform will enable research that will make Virtual and Augmented Reality applications. These applications will help a first responder to navigate a burning building to find a victim. High bandwidth 5G networks will allow high resolution drone video to be shared with incident command within seconds rather than the hours that are required for our 4G networks. The applications that will be supported on the AWARE platform will enable 3GPP, IETF standards based interoperability of real-time collaboration tools that will eventually enable voice, video, text and chat communications between first responders over the 5G networks anywhere in the world. These public safety applications will include 5G drone delivered services, application service delivery in an environment lacking infrastructure and device to device communications.

Mobility – We have successfully shown, through concepts, simulations, and field tests, how vehicle-to-vehicle and vehicle-to-infrastructure communications and radar systems can substantially reduce crashes. As an example, for warning before an unprotected right turn, our results indicate that radar and V2V wireless communication can detect and prevent 35% and 77% of crashes, respectively. A combination of the two achieves a crash reduction of 90%. The facilities at Texas A&M's RELLIS campus and UT Austin's main and Pickle campus have been designated as Autonomous Vehicle (AV) Proving Grounds by the US Department of Transportation, and many of the field studies in the context of safety considerations associated with commercial fleet movements, vehicle movements, and pedestrian/bicyclist movements are being undertaken at these facilities. Deep learning and distributed intelligence systems are being combined with innovations in hybrid sensing-communications technology in the field experiments, which can be further facilitated with the AWARE platform.

IoT – With proliferation of sensors and connectivity, the IoT platforms are providing ample opportunities for development of novel applications in health-care, home automation, mission-critical public safety and industrial automation among many others. The combination of sensing and connectivity provides unprecedented opportunities for access to data using standardized communication frameworks. The unmet needs remain in the lack of guarantees in the timeliness of the data delivery, and potential challenges associated with the robustness of communication, in particular in presence of higher bandwidth data streams. Current applications of IoT are constructed with the assumption that there is often no hard timing constraints for the data delivery, or if there is a time constraint, lack of adherence will not lead to a safety failure. This assumption does not lend itself to mission critical or precision applications. We envision that the IoT is expected to provide rich contextual information about the environment and the integrity of the information and the timeliness of the delivery must be guaranteed. For example in a scenario where the law enforcements are responding to an active shooting incident, a real-time, holistic and yet thorough view of the environment will assist the law enforcement to contain the incident effectively. The IoT is expected to provide real-time information to the first responders pertaining to the rapidly changing condition of the environment, perhaps via augmented reality (AR), and the end-to-end delay for data delivery

including processing overhead must remain around 10-50ms to enable a naturalistic interaction of the personnel with each other and the environment

Secondary Application Use Cases

Network slicing – The open flow architecture P4 enabled software defined network architecture of the AWARE platform will allow network slicing research. Most IoT data sources can support several diverse verticals. A single surveillance video source for example can support public safety in both prevention and forensics, community planning, transportation management and several other functions which may have diverse requirements..

DoD – DoD and the Army (Regular Army, Reserve and National Guard) in particular conduct military and public safety operations, frequently in partnership with other nations, in areas utilizing DoD as well as indigenous infrastructure. The Army is actively pursuing programs such as the Internet of Battlefield Things (IoBT) which closely parallel civilian applications. The Army Research Labs (ARL) would work with AWARE in support of their mission.

Infrastructure – The AWARE platform while focusing on applications needs to also support the underlying infrastructure. This infrastructure includes;

Three sets of dense 5G nodes, one at Disaster City at a 250 acre public safety training facility that trains 180,000 first responders per year (15 cell sites/km^2), a second at the US DoT approved autonomous vehicle facility at the RELLIS campus (9 cell sites/km^2) and the third at Riverside Drive in Austin, which is a growth area selected by the City of Austin for its population diversity (15 cell cites/km^2. The first two sets of sites are in College Station on the Texas A&M University (TAMU) Campus and provide controlled areas for public safety and mobility research. The third site in Austin allows researchers and the public access to each other. All components of the 5G cellular sites would be remotely configurable by experiments using the established Emulab Control. This design would support both the diversity, usability and the sustainability visions of PAWR.

To support applications, we are adding an Open Flow Software Defined Network (SDN) architecture that is P4 enabled, which would enable end-to-end network slicing to support applications with strict network requirements. The portion of the AWARE platform is supported by a partnership with the UNC networking team that has broad experience in supporting GENI and Juniper. All of this would support the open access and interoperability vision of PAWR.

A set of robust application servers would be installed on the platform that would be required to support specific vertical sectors. These application servers would include IP Multimedia Subsystem (IMS servers) to support voice and video signaling, Mission Critical Push to Talk (MCPTT) to support land mobile radio applications, EBMS servers to support multi-way video. To manage these servers for experimentation, we would use the server's APIs to add remote control using the established Emulab control architecture. These application servers would be made available to other PAWR platforms. This supports the usability and programmability vision of PAWR.

The AWARE platform would provide access to cloud, edge cloud and high performance computing capabilities to support the researchers. The cloud would be used to archive test results, the edge cloud provisioned at each cellular node would provide zero latency computational power for applications, and the high performance computing nodes would provide high speed (40 gigabit per second) access to HPC services where needed. This would support the reproducibility vision of PAWR.

Advanced Wireless Application Research Environment (AWARE): Texas A&M University

Research Community – The research community behind the AWARE platform is broad and diverse. It includes Universities, Federal Agencies and Labs, Industry and the DoD. The research community that has engaged the AWARE platform includes a diverse community in the United States and around the world.

Universities that are involved in the AWARE platform initially include researchers from the University of Texas working in 5G wireless, mobility, network slicing research, and policy considerations related to ethical, responsible and equitable data use.

Texas A&M University System components are working on MAC layer 5G wireless enhancements, heterogeneous wireless networks, IoT, mobility, public safety and smart grid areas of advanced wireless. A collaborator, Texas State University is working on edge computing and offloading techniques for augmented reality applications, low latency IoT data transfer and energy efficient networking algorithms.

The University of North Carolina is contributing in the area of software defined networks and extending the GENI capabilities to the device mac layer. Open Flow GENI networks would be extended to not only all of our campus partners but to federal research labs for data sharing. Leveraging the North Carolina expertise in managing Open Flow networks, our proposal could extend the SDN network to the existing COSMOS and POWDER RENEW platforms creating a large virtual platform.

The UVA researchers are bringing expertise to the platform in IoT architectures, 5G circuit design, DC power management and Terahertz networks. Penn State University is providing expertise in antennae design, and the University of Ohio is augmenting TAMUs heterogeneous wireless network efforts.

Federal labs collaboration from day one would include the NASA Jet Propulsion Labs (JPL) that is working with the Department of Homeland Security on artificial intelligence research to collect IoT data to create first responder analytics engines. We would provide a live feed of IoT sensor data collected from sensors at Disaster City to JPL in support of their efforts. We would also provide AWARE video feeds from the same source to the NIST video research facilities in Gaithersburg to support their facial recognition research. The recently created Army Futures Command that recently relocated in Austin Texas is working with the AWARE planning team to support DoD efforts in the use of advanced wireless war fare technologies. This includes possible connection to the Army Picatinny Arsenal in New Jersey where they lead Army advanced communications research efforts in the Network Enterprise Center.

Industry support is also as diverse. We are currently working with Nokia on use of their IMS architecture to support applications. Crown Castle is supporting infrastructure placement Both AT&T and Verizon have expressed interest in involvement in the 5G efforts at Texas A&M University, the University of Texas at Austin and the City of Austin. At this time there are at least 20 other industry supporters.

Lastly the AWARE platform has support from the International community. Defense Research – Development Canada (DR-DC) Centre for Security Science (CSC) has an ongoing research initiative with TAMU in 4G technology and would join AWARE as a 5G partner were it to be funded. Furthermore, DR-DC is attempting to bring the UK and Australia into this collaboration. The cloud environment of AWARE would be used to collect radar data collected from the Gulf of Mexico from sites in Mexico and Cuba. This data is used to study the impact of gulf currents that can be used for weather (hurricane) predictions and crash victim rescue from airplanes and ships. The 5G AWARE platform would be used to provide application support to the 5G Innovation Center in University of Surrey in the UK.

Advanced Wireless Application Research Environment (AWARE): Texas A&M University

Community Engagement – The success and long-term sustainability of this research grant depends on the collaboration and support of multiple communities that bring diverse points of view -- namely, research institutions, industry partners, and local community stakeholders.

Our guiding principles for community engagement strengthen overall research outcomes. Throughout the grant period and beyond, the shared principles of *Equity and Community Benefit, Co-creation and Collaboration,* and *Sustainability* among stakeholders will ensure that the research grant:

- Delivers real societal benefits and equitable community development through participation of diverse groups and public engagement with science.
- Operates with support from research institutions, industry partners, and local community, integrating these perspectives in the design, implementation, and iteration of the research.
- Spurs the transfer and commercialization of research findings and outputs.
- Builds capacity and community buy-in to sustain the research and its benefits over time.

The Austin site targeted for this research is located in a rich, diverse, and active community of residents and businesses, with also quite substantial pedestrian movements as well as vehicular movement. Through this research, we aim to co-create equitable benefits for the residents, businesses, as well as different types of road-users in the area -- including the voices of these people in addressing neighborhood-specific needs and priorities.

As a core component of our initiative we will create an Advanced Wireless Innovation Lab in our selected service area. It will house a 5G node and access to high performance wireless devices. As a community driven and managed innovation lab, we will foment the development of high bandwidth and low latency applications. By leveraging our vast innovation and entrepreneurship network we expect to not only attract bleeding edge participants but, most importantly, to recruit and develop local community members regardless of their socioeconomic and education background – as we have done in other underserved communities.

Our community engagement is a collaboration between three broad groups of stakeholders

VALUE PROPOSITION
AWARE proposes a common approach to community engagement that will enable stakeholders to benefit through a process of 1) Discovery & Planning, 2) Co-Creation, and 3) Sustainability.

// Partners // // Value // // Goals //

Activate researchers to collaborate and achieve breakthroughs on the AWARE platform.

Value to Research: Share knowledge and applications.

- Texas A&M University
- UT Austin
- Texas State University
- National Research Institutions

Engage industry in accessing technologies and the AWARE platform

Value to Research: Spur technology transfer and economic development

- PAWR Industry Consortium
- Major companies
- Startups and entrepreneurs

Empower local residents, businesses, and government to shape research and realize community benefits

Value to Research: Inform with real-life experience and sustain research over time

- Texas Innovation Alliance
- AdventGX
- Technology, Education, and Workforce Nonprofits
- Local School Districts

Advanced Wireless Application Research Environment (AWARE): Texas A&M University

Alignment with the PAWR Vision

1. **Reproducibility of research** – The AWARE platform is designed in a fashion that all data collected for every experiment will be collected, annotated and archived for future researchers. This will include the configuration files for every element, the syslog files from the experiment, the waveforms from the RF systems and the data transported.
2. **Usability –** The AWARE platform intends to utilize the Emulab platform developed at the University of Utah for the elements that embedded in both the AWARE platform and the Utah platform such as the SDN radios, switches etc.
3. **Programmability –** The Aware project will develop the Emulab interfaces for the application layer servers such as the Mission Critical Push to Talk Application Servers, the media servers (both video and voice), the Multimedia Broadcast Multicast Service (MBMS) and other services that are required to support the application layer.
4. **Interoperability –** All of the functional elements of the AWARE platform will conform to IETF, 3GPP, IEEE, ATIS, ETSI and other standards where ever possible.
5. **Open Access –** By utilizing the Emulab platform it should be possible for researchers to conduct their experiment without ever having to visit Texas. In addition the SDN, GENI SDN architecture will allow us to support layer 2 services to a research facility anywhere in the world.
6. **Diversity –** While the target market segments of the AWARE platform are public safety, mobility, and IoT, the platform is being designed to support other segments such as energy and health.
7. **Sustainability –** The shear diversity of the AWARE platform ensures sustainability. Future federal agencies, equipment manufacturers and application developers in any market segment that require an established ecosystem to further their research initiatives will find a cost effective home in the AWARE platform. In addition, we are able to provide a diverse community of first responders mobility and other users to validate the services.

Implementation Plan The ITEC team has significant experience in designing and implementing testbeds and large scale experiments. From our first project funded in 2007 by the US Department of Transportation in which we designed, developed, deployed a tested which was the first NG 9-1-1 system in the world. This project involved Booz Allen Hamilton and Columbia under a collaborative effort. In 2010 we received $10 million in funding under the US Department of Commerce Broadband Technical Opportunities Program (BTOP) to construct fiber optic networks in 12 communities in Texas that involved 5 independent telephone companies, several communities and over a dozen universities. This was a three-year project with hundreds of moving parts that was completed on time and under budget.

We are also leveraging the largest public safety training facility in the world, a US DoT approved autonomous vehicle test track, and an FAA approved Unmanned Aerial Vehicle (UAV) test facility. The use of a tier four data center recently built on the TAMU campus for one of our cloud services will facilitate the requirement to have the servers online within the first year. This facility is already hosting an Oracle Cloud platform. The city of Austin is a well know leader in the smart and connected community world in having reached agreements with Google on their Broadband initiative. The city is working with us to manage permitting and licensing for the Austin node sites. There are pre-bid fiber installation contracts that are FCC approved for e-rate that will be used to installation of the fiber optic network. These existing resources will enable AWARE to meet or exceed all of the PAWR construction timeline requirements.