1) **Proposed Research Focus:**	**Smart Support Systems for Aging Population (SSSAP)**				
2) **Primary Contact Persons: Mohsen Shahinpoor**					
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3) **Suggested/Potential Key Senior Personnel:**					
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4) **Potential Senior Personnel & Collaborators:**					
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5) **Intellectual Merit: (the research focus)**					

A. *Need: a brief statement of the research problem/need to be addressed, and why it is urgent for Maine to address this problem/need now (how it is currently limiting the state's capacity/research competitiveness).*
Aging research is considered an emerging area of excellence for the University of Maine System. By 2031, the oldest group of baby boomers will turn 85, leading to a bulge in the aging population in the State of Maine and with an anticipated rise in age-related problems for this population. Thus, there is a critical need to better prepare the related infrastructure in the State of Maine to adequately support the growing aging population of the state. In that spirit, we propose to conduct critical research on smart support systems to enable safe and stable mobility for the aging population of Maine. Mobility also has a strong bearing on the elderly population's propensity for Falling, Frailty, Gait Dysfunction, Cognitive Impairment in Mobility, Diabetes and Diabetic Peripheral Neuropathy, Pressure Sores and Foot Ulcers. It is quite clear that safe and stable mobility plays a prominent role in competitive aging related research. Thus, we need to develop unique expertise in the translation of smart materials and wearable technologies for more accurate movement assessment of elderly population in their natural environments.

B. *Research Goal & Objectives: describe the overall project goal to address this problem/need &key research objectives.*
Our overall goal is to build a research infrastructure and the required capacity to support statewide, multidisciplinary competitive research in improving the quality of life and health of the aging population of Maine and subsequently translate that to other aging, geriatrics and gerontology populations in the US and the world. **Overall Objectives of the proposed effort are:** 1- Determine the safest and most stable assistive, mobility and wearable materials and systems for convenience and comfort of the aging population, 2-Expand Maine's competitive research capacity, aligned with an MIEAB defined target sector such as "Aging Research", 3-Create STEM and workforce development opportunities in connection with assistive technologies, smart materials and smart wearables for the aging population, 4-Facilitate the expansion of smart support systems for the detection/monitoring of proprioceptive sensing issues of falling, gait dysfunction, frailty progression, cognitive impairment affecting mobility and diabetic foot ulcers and pressure sores.

C. *Research Actions: describe a few specific key research actions that could be implemented to meet the objectives. Feel free to withhold any information deemed sensitive, given this information will be shared with the community.*
Our research actions start with investigating the potential applications of smart multi-functional materials towards addressing the aging, geriatrics and gerontology problems. We will investigate how multifunctional smart materials can help the aging population sense and monitor their discomfort and react correctly to alleviate any discomfort. Our research will explore the potential of various multi-functional smart materials to monitor and improve aging and geriatrics-related changes in the neuromuscular system of the elderly. Our research actions will further explore the possible and potential applications of the specific family of smart materials and how it can address some of the critical areas of gerontology including devices for home rehabilitation, remote monitoring, social well-being, frailty monitoring, monitoring of diabetes and wound healing and fall detection and more. We follow with a brief description of currently available smart materials with potential to ease common problems among the elderly. The emphasis is normally on the applications employing the smart sensing to address various aging problems. Piezoelectric and piezo resistive sensors and actuators can be applied to

aging research to generate proprioceptive sensing feedback to patients. They generate a force upon actuation and can be designed to generate human-friendly forces and stresses in the few mega Pascal (MPa) range towards understanding proprioceptive feedback and frailty. They can sense heat and temperature variations which affect their actuation and sensing characteristics. They are also used in medical infusion pumps for bladder irrigation. Figure C.1 depicts how piezo resistive force/pressure sensors and the associated software show the pressure distribution over an area of medical interest with graphical display. These sensors can rapidly and accurately identify physiological frailty in older adults by sensing arm movements and determination of Trauma-Specific Frailty Index (TSFI). Figure C.2 displays a pair of smart socks with smart fabrics embedded into sock form factor that track force, cadence and gait variables. Note the connected flexible Bluetooth receiver and soft port on the ankle. Figure C.3 depicts a novel wearable arm device for the elderly, which uses sensors found in cell phones to sense and rapidly and accurately identify physiological frailty in older adults. Due to lack of space we simply list the smart materials we will be investigating in our research towards improving the stable and safe mobility of aging population. These smart materials are giant magneto-strictive materials for urethral magnetic
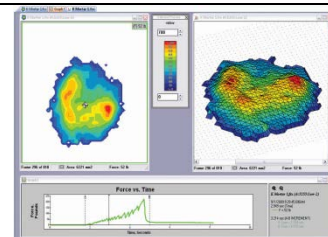

Fig C.1-Skin Pressure

Fig C.2-Smart socks

sphincter applications to correct incontinence. Similarly, giant magneto resistive materials may solve some specific problems in connection with frailty monitoring of older people. The additional potential smart materials and wearables we will be investigating are dielectric elastomers, shape memory materials (SMMs), magnetorheological fluids, Graphene, Ionic Polymer Metal Nano Composites (IPMCs) and carbon nanotube. Particularly in connection with shape memory alloys (SMAs) there are good possibilities of improving the quality of life and health of the elderly by correcting scoliosis (abnormality of spine) and aging-related applications and wearables. Fig. C.4 depicts smart wearable mobility supports equipped with SMMs for the elderly.

Fig C.3-Wearable Arm Device
Courtesy-Baylor College of Medicine

Fig C.4-Smart Wearables

D. Priority: *indicate how this research would address NSF and state priorities in advancing the frontiers of knowledge and understanding (within a field and/or across different fields).*

This research is in harmony with NSF's 10 Big Ideas, 'The Human-Technology Interface' as well as NSF Division CBET and its research funding program on General and Age-Related Disabilities Engineering (GARDE). It further aligns with the State of Maine's priorities in connection with critical research needs in aging, geriatrics and gerontology (Maine's 2010 S&T Plan).

E. Other Potential Synergies: *if applicable, list other potential research synergies that may become part of the proposed or future research agenda for this project.*

The proposed research will also benefit the athletic youth of Maine in terms of mobility gauging and monitoring. Furthermore, the infrastructure created will be utilized in the future to team up with neighboring States' aging research programs.

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

F. Impacts: *potential to benefit society and contribute to the achievement of specific, desired societal outcomes.*

The smart assistive systems, materials and wearables investigated and developed for the aging population of Maine can also certainly be utilized by younger generation and athletes of Maine to monitor their mobility and bodily functions.

G. Impacts: *potential economic development as a result of this research.*

This research will enhance Maine's economy by improving the quality of life and healthcare of the aging population of Maine. It will also help energize the aging population to pursue a more active lifestyle that could support the economy.

H. Impacts: *potential for statewide workforce development in this research area*

The proposed research program will also increase academic R&D capacity; bolster collaborations among Maine's Institutes of Higher Education (IHEs) and private companies; support doctoral students in a wide range of disciplines; and develop workforce through increased STEM training.

I. Impacts: *potential to provide infrastructure that grows the state's academic research and education capacity*

The associated *infrastructure* will be utilized for additional NSF grants. New grant proposals will target aging research funding programs across the nation to build a statewide education program for helping the Maine aging population.

7) Management:

J. Brief description of what your research project management structure might look like.

We anticipate that our team will be part of a bigger NSF-EPSCoR team addressing all issues in connection with aging, geriatrics and gerontology in the State of Maine.

8) Suggested areas of expertise for reviewers:

Geriatrics, gerontology, proprioceptive sensing materials, smart wearables to monitor frailty, falling, dizziness, gait dysfunction and mobility problems, peripheral neuropathy sensors for monitoring diabetic foot ulcers.