Exhibit should describe:

- **The complete program of research and experimentation proposed including description of equipment and theory of operation.**
- **The specific objectives sought to be accomplished.**
- **How the program of experimentation has a reasonable promise of contribution to the development, extension, expansion or utilization of the radio art, or is along line not already investigated.**

We would like to obtain a license to operate a new research device we have developed at MIT. The device emits an UWB signal (between 5.46-7.25GHz) at very low power in compliance with FCC part 15, subpart F, section 15.517 for low power, UWB indoor systems.

In this exhibit, we describe the program of research, objects, and promised contributions.

Program of Research:

Goal of Research:

The goal of this research is to study RF-based location and motion tracking of users without wearables for health-related applications. The research program aims to develop a wireless sensor that transmits a low power signal and uses its reflections off objects and people in the environment to track motion and trajectories. The sensor has medical applications for fall detection of elderly, gait estimation of patients with musculoskeletal and neurological diseases and behavioral tracking for patients with dementia, Alzheimer's disease and cognitive disorders. The sensor can also detect smaller motions such as breathing and heart rate, and hence has applications in detecting sleep apnea and other respiratory problems. The research will be conducted by MIT researchers, in collaboration with medical doctors from top hospitals such as Massachusetts General Hospital, Brigham and Women's Hospital, University of Rochester Medical Center and more . Hence, an important goal of the research is to study the impact of indoor multipath and the interaction with various materials.

Theory of Operation:

The proposed devices emit a low power continuous FMCW (Frequency modulated carrier wave) signal and capture the reflection off different objects in the environment. By measuring the time of flight of these reflections, it can then infer the locations of the different reflectors and localize them. We develop algorithms that use these location estimates to infer user's locations, gesture movements, and vital signs.

Experimentation:

We plan to perform three types of experiments, all of them in indoor environments:

- The first type deploys the device in various rooms of a building and uses the reflections to track people's movements, and infer their gait and location
- b) The second type of experiments deploys the device near a user to detect breathing and heartbeats and provide this information to our research collaborators.
- c) The third type of experiments asks users to perform various gestures and uses the RF reflections to interpret these gestures.

Equipment:
The device consists of an FMCW transceiver connected to WAJ5B antennas at the front end and to a laptop that runs our signal processing algorithms. The description of the antennas and emission specifications are described in the rest of this application including a separate exhibit that details the power requirements.

Objectives of Research:
The objective of this research is to explore the ability of wireless signals to enable non-contact monitoring of human motion and vital signs. We detail three of our main objectives:

- Detecting and predicting elderly falls, thus reducing the severity of the injuries resulting from these falls.
- Monitoring vital signs in non-contact and non-invasive method and providing this information to medical doctors to test for sleep apnea and arterial fibrillation without any contact of the subject's body, which would enable at home testing and cost reduction for hospitals and patients.
- Enabling gesture control and smart homes that can track and adapt to users' habits and lifestyles.

Promise of Contribution:
Today, more than 80% of the elderly population live in their homes, and desire to remain independent. This desire, compounded with the high costs of moving seniors to specialized elderly facilities has resulted in an urgent need for aging-in-place technologies. By enabling non-intrusive continuous monitoring of vital signs, falls, and motion patterns, the research helps elderly live safely in their homes. Beyond elderly monitoring, the research would improve our health-awareness by providing daily reports on our health progress. It can also reduce the cost of hospitalization by allowing hospitals to discharge low-risk patients and monitor them remotely via our technology. It also has wide-ranging applications including the detection of sleep apnea and remote monitoring of heart disorders such as arrhythmias and cardiac arrests. Finally, the research is integrated with education and outreach programs that include inter-disciplinary classes. The results of the research will be disseminated not only by publishing in academic venues, but also by leading tutorials and workshops, and working with local hospitals and elderly care organizations.