Project: Dual-Use Optical Sensors for Advanced Military Applications

Brief Description: Montana State University requests $1.6 million to work with the U.S. military and Montana optics industries to apply optical environmental sensors to improve advanced polarization-based military surveillance.

Executive Summary: The U.S. military is developing new sensing and surveillance technologies based on polarization imaging, which adds information beyond what can be achieved with brightness- and color-based imaging. The effectiveness of this new technology will be greatly enhanced by applying environmental remote sensing instruments to generate improved models of how the atmosphere affects the polarization signatures observed in military measurements.

Project Description:
We propose an interdisciplinary research program at Montana State University (MSU) to deploy combined active and passive optical remote sensing systems to characterize the effects of the atmosphere on polarization signatures that are being exploited in advanced military sensing. This dual-use effort will draw on sophisticated environmental sensors to quantify the effects of a variable atmosphere on advanced military sensing applications.

The U.S. Air Force Research Laboratory (AFRL) is beginning to exploit polarization for enhanced detection of man-made objects from the air and space, through camouflage, in shadows, and during day and night. The polarization signatures measured by military sensors provide an incredible ability to see targets that were previously hidden. However, these optical signatures are also strongly influenced by the atmosphere – through scattering by clouds and dust, etc. Therefore, the utility of this advanced technology will remain limited until the environmental effects are carefully characterized.

The AFRL has developed an impressive ability to provide enhanced target detection with long-wave infrared polarization imaging, but are now moving into the mid-wave and short-wave infrared spectral region where much better detectors are available and more detailed images can be obtained. However, atmospheric effects are much more severe in these spectral regions, and their influence on polarization imagers almost entirely uncharacterized.

This program builds on novel optical sensing systems that MSU has developed to measure atmospheric effects and polarization signatures. We will use these environmental sensors in collaboration with AFRL personnel to assess the influence of variable atmospheric conditions on polarization signatures of military interest. These measurements will lead to dramatically improved accuracy and reliability of the military polarization imagers.

Congressional Action Needed: An appropriation of $1.6 million is requested.

Importance to Montana and the nation: This work will further strengthen and diversify the rapidly growing synergy between MSU research and the Montana optics industry. Growth in this field has been especially strong in the Bozeman area because of collaborations with and technology transfer from MSU. The requested appropriation will involve direct collaboration with a brand new Bozeman optics company that was recently created to commercialize technology that will be part of this project. This project also will increase collaboration between MSU and several existing Bozeman optics companies (especially Resonon, Inc, FLIR Systems, Inc., and Big Sky Laser Technologies), who manufacture optical systems that will be key components of this effort. This work also will strengthen the ability of MSU to train the highly educated work force needed for these industries.

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Project: Dual-Use Optical Sensors for Advanced Military Applications – Talking Points

- Widely recognized MSU atmospheric sensors will be used for DoD applications:
    - This project will apply widely recognized MSU expertise in optical remote sensing technology and atmospheric measurements to providing a firm quantitative basis for understanding polarization measurements in an outdoor environment.
    - Advanced lidar systems developed at MSU for climate research will be used to measure aerosols, water vapor, and clouds, all of which have a significant role in determining the polarization signatures of military targets observed outdoors.
    - MSU is the world leader in developing and using all-sky polarization imagers for studying the variability of skylight polarization with aerosols and clouds (this will be used to study polarization signatures from simulated military objects).
    - MSU is also the world leader in using wide-angle infrared cloud imagers to measure cloud type and distribution (these sensors will also be used to quantify the dependence of polarization signatures on cloud type and distribution).
    - MSU expertise in tunable diode lasers and diode-laser-based sensors place us in a strong position for developing ultra-compact airborne sensors.
    - This project will expand our sustainable suite of instruments at MSU that can be used for a wide range of sensing applications relevant to the DoD.
- J. Shaw has a strong record of measuring and modeling polarization in outdoor scenes (he published a widely known paper on atmospheric effects in long-wave infrared polarization signatures and more recently two papers on aerosol and cloud effects on visible polarization).
- J. Shaw is a widely recognized leader in the polarization sensing community, serving as the co-chair of the SPIE *Polarization Science and Remote Sensing* conference and frequently giving invited talks at military sensing symposia.
- J. Shaw has a record of working successfully with military researchers to apply environmental remote sensing expertise to military sensing applications (current collaborative relationships with AFRL at Wright Patterson Air Force Base in Dayton, OH, and at Kirtland Air Force Base in Albuquerque, NM);
- Project partners, K. Repasky and J. Carlsten, are widely recognized leaders in the development of novel lasers and laser sensors;
- J. Shaw has developed and applied lidars and imagers to airborne applications;
- K. Repasky and others are deploying compact hyperspectral imagers made by Resonon, Inc. on unattended aerial vehicles (UAVs) and small aircraft;
- J. Shaw and others are developing novel calibration schemes for airborne hyperspectral imagers in collaboration with Resonon, Inc.
- J. Shaw's recent graduate student, P. Nugent, just formed a **new Bozeman optics company** to commercialize compact infrared sensors that will play a key role in this project; therefore, this work will directly strengthen both MSU efforts and help establish a commercial market for sensors to be sold by a new Bozeman company.
- The MSU faculty members working on this proposed effort have been involved with numerous small companies in Montana, including Resonon, Inc., FLIR Systems, Inc., Big Sky Laser Technologies, AdvR, ILX Lightwave, S & K Electronics, etc., and have a notably dedicated and successful record of technology transfer.
- In this project we plan to conduct a field experiment at Malmstrom Air Base to assess the effect of mountain wave clouds on polarization signatures. These clouds, which have unique optical properties, are particularly common in locations on the leeward side of mountain ranges (as is the case for Malmstrom).