Technical Evaluation Report

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A welcoming address was given by Col. Wolf, Commander of Julius-Leber Kaserne and opening remarks were provided by Dr. Reinhard Ebert, Symposium co-chair.

Session 0, SET-094 Symposium on "Emerging Electro-Optic Phenomenology and Technology", was unclassified and contained a keynote presentation by R. Richter in which he discussed major requirements for the successful operation of hyperspectral imaging sensors and the methods used to fulfill these requirements. He outlined methods for target discrimination using the compiled full spectral database of the hyperspectral imaging sensors as well as compression algorithms. He also gave examples of radiative transfer codes able to convert the at-sensor radiance to surface reflectance or emissivity.

Session 1, New Sensors and New Approaches, was NATO PfP (Partners for Peace) unclassified and started with a presentation by T. Apostolova on new ideas for tuning the wavelength response of detectors throughout the IR, and possibly into the terahertz region, using applied electric and magnetic fields and unconventional biasing methods. A device concept was also described for detecting the full polarization vector of the signal within a single pixel of a quantum well detector as well as a concept for cooling the detector directly on the chip, pixel by pixel. All these new ideas were oriented to support space situational awareness missions, while optimizing detector design. These advances will also reduce detector size, weight and eventually their cost and at the same time increase their reliability. Next H. Hovland presented a new technology utilizing image reconstruction techniques used in tomography. It was demonstrated how the addition of moving apertures can enhance the acquired images. The next presentation by K. Lukin described a new optoelectronic device enabling multiplication of carriers inside a multilayered semiconductor structure and outlined the possible design of such a device to be used as a solid state photomultiplier for detection of weak signals.

Session 2, Acquisition and Analysis Procedures, was NATO PfP unclassified and opened with a talk on thermal emissivity separation algorithms which are essential for sensors operating in the thermal infrared bands since they allow the extraction of two fundamental target characteristics- emitted radiance and temperature. The former gives information about the target materials and the latter gives information how these materials are related to the environment. Next R. Richter provided a description of a de-shadowing technique for multispectral and hyperspectral imagery over land. This technique is essential when imagery of Earth's surface is contaminated with cloud/cloud shadow areas and utilizes the fact that despite the complete blocking of the direct solar beam in shadow regions, there remains the reflected diffuse flux. T. Skauli gave examples which illustrated the potential benefits of spectral imaging for target detection in the last presentation for the session. Hyperspectral images of simple target objects in different backgrounds were analyzed and results were presented for simple anomaly detection as well as for detection based on known spectral signatures. For anomaly detection a statistical model of the spectral distribution of the background is used and a probability value for each pixel is calculated, low probability indicating the presence of a target.

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It was concluded that the use of spectral image information improves the detection and classification of targets because it facilitates clutter suppression in images, hence reducing the probability of false alarms in a detection system.

Session 3, Passive Collection Systems, was NATO PfP unclassified and A. Muller started the session with the description of a new airborne reflective emissive spectrometer (ARES). This spectrometer is expected to cover both the solar reflective region and the thermal region and hence provide the thermal signatures and reflectance spectrum of natural materials such as mineral mixtures. Information extraction based on the state of the art spectral evaluation algorithms was introduced as well. The following presentation by J-M. Garneau described the instrumentation and preliminary results of the Canadian airborne hyperspectral imager development. The spatial sampling of the imaging system measures emissions in the band from 2 to 12 microns by acquiring data with two detector arrays using InSb and HgCdTe technologies to cover the spectral region, and broadband imaging of the system is achieved by three sets of cameras-visible, MWIR and LWIR. R. Hintz concluded the session by discussing an Infrared Search and Track system that uses an existing passive MWIR sensor integrated with an eye safe laser rangefinder that can be operated from an unmanned air vehicle with automated targeting and fire control functionality. This sensor is intended to operate against a large range of targets with large variation in their signatures, for example detecting low flying aircraft and also tracking missiles launched from shipboard platforms.

Session 4, Active Collection Systems, was NATO PfP unclassified and commenced with Y. Fedulov describing a method for object image classification based on similarity measure as an important instrument of data analysis. The next presentation by D. Letalick described the advantages of laser radar imaging in providing intensity and range information which adds an additional dimension to an image. Examples were given of three dimensional data from objects which were either partially concealed or behind windows with blinds or inside vehicles. The principles of operation of the 3-D imaging laser radar were described and the present limitations of the emerging 3-D sensors with on-chip signal processing for achieving high resolution were mentioned. The last presentation in the session given by H. Becht evaluated laser profiling and gated-viewing systems for ground-based applications. He described the laser profiling system design and provided measurement data on armored vehicles and its suitability for automatic target identification. The performance of the gated viewing system using a laser range finder and a camera was compared to the one of the eye safe laser profiler and the advantages and disadvantages of using one or the other for imaging were pointed out.

Session 5, Military Utility and Countermeasures, was NATO classified and opened with a keynote presentation by Y. King explaining in detail the importance of analyzing how a given technology is going to be utilized for military purposes and building that knowledge into the process of developing a given technology. Next J. Fortin presented a description of a Laser Imaging and Neutralization Tracker system capable of precisely detecting and locating laser beam riders and consequently defeating them using an eye-safe laser-based countermeasure to disrupt their tracking and aiming task. The following talk by B. Molocher described an airborne self-defence system designed to protect against heat seeking missiles. The last presentation by D. Titterton covered the historical development of on-board jammer systems through laser-based devices for enhancing the survivability of space aircraft against missile attacks.

Session 6, New Methods, was NATO PfP unclassified and started with a presentation by M. Muenzberg on the linking of different computer platforms to an information network with new capabilities, and adapting the concept to war fighting forces and satisfying mission-related requirements like distributing image data of a threat, implementation of imbedded training, etc. The next talk, presented also by M. Muenzberg, was a review of the current status at their facility (AIM) on quantum well infrared photodetectors (QWIP) and antimonide type II superlattices (SL) detection modules for ground and airborne applications in the high

performance range. He explained the advantages and disadvantages of using QWIPs and superlattices for detection, and dwelled on the specific advantages of a dual color detector for missile approach warning, such as using spectral information to discriminate efficiently between sunlight reflections, background clutter, etc. and a missile. He showed results on how the red/blue ratio allows one to clearly discriminate the threat from the background clutter. His conclusions were that the QWIP technology is the only affordable one that provides dual band imagery, using a dual MWIR and LWIR FPA. He also pointed out that the superlattice technology is also available for dual color imagery in the MWIR, and extremely low spectral cross talk from the red to the blue wavelength was measured in visible region. The session was concluded with a review of the THz-related science and technology program, its recent progress and future directions by D. Woolard. It was noted that the THz regime offered technical advantages to the traditional radio-frequency microwave and the infra red domains such as wider bandwidths, improved spatial resolutions, etc, as well as new sensing modes such as concealed weapon detection, and chemical and biological agents detection. The challenges pertaining to the THz regime were identified as well - atmospheric attenuation, weak interaction signatures, standing wave interference. Several research efforts were outlined: 1) a THz interaction mechanism related to biological and chemical agents and aimed at developing a scientific base for THz frequency sensing. This will lead to the demonstration of resonant signature phenomena in solid films of DNA, proteins, tissues and biomaterials in liquid phase. The application of THz spectroscopy for biomedical research was discussed, including the development of THz characterization techniques for solutions of biological materials for real time monitoring of biological processes. The use of THz transmission spectroscopy for structural characterization of proteins and nucleic acids was also discussed. 2) The creation of compact and reliable sources of THz power and full frequency domain THz spectrometers was discussed. These will yield military viable THz technology for use in portable spectrometers for stand off detection of explosives and chemical and biological threats and can be used in the design of a lower frequency (210-270Ghz) heterodyne spectroscopic system prototype, and an interband-resonant-tunneling diode-based frequency oscillator; 3) The creation of a novel type of photomixer-based hopping spectrometer was described, in which sensitivity will be increased by orders of magnitude by the use of coherent transmitter and receiver with the goal to achieve measurement capabilities that can be rapidly tuned in discrete steps (1GHz) across the entire THz ban. This will result in rapid identification of associated THz spectral signatures of biological materials.

Session 7, New Modalities, was NATO PfP unclassified and in the beginning R. Ebert described the propagation of ultrashort (<50fs) laser pulses in the atmosphere and the phenomenon of strong “white light generation” due to high intensities and the potential of this laser threat to disrupt sensors. The results from the experiments outlined in the presentation were that nonlinear effects such as reversed saturable absorption in fullerene suspensions and nonlinear scattering processes by carbon nano-particles (Astralen), with the two materials being examples of conventional and non-linear laser protection filters, exhibit a significant optical limiting behavior with respect to nanosecond pulses, but do not perform well for femtosecond pulses, which implies a new challenge for protection against the latter. The next paper by R. Buser described complete Stokes imaging polarimeters developed to investigate polarization phenomenology and to quantify expected improvements to target acquisition and mine detection. Several example studies were presented to point out that infrared polarization imaging gives better discrimination when used with thermal imaging, and although the polarization signal in MWIR spectral band is dominated by solar reflection, polarization measurements in the LWIR add knowledge to the hyperspectral imaging by suppressing background, improving detectability of man made objects and shape estimation, etc. The last presentation by E. Pukrin described a method for passive standoff detection of chemical warfare agents and toxic vapors by using Fourier-transform infrared radiometry (FTIR). The method is based on the use of a double input beam FTIR interferometer and its differential detection capability that provides two unique features for a field deployable instrument: constant calibration providing reliable quantitative measurements over a long period of time, and a real time optical subtraction of the background signal from the target signal providing a target signature minimally perturbed by the

background radiation. These two capabilities render the FTIR interferometer especially useful for remote monitoring of battlefield environments since it can provide unique information concerning ongoing maneuvers.

A summary was provided by Dr. Take at the end of the formal presentations.