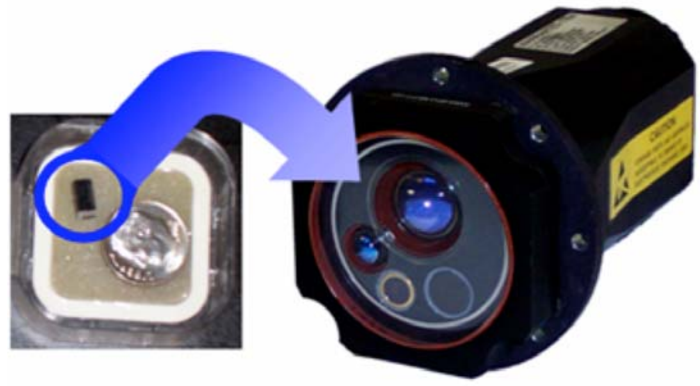
Integrated Hostile Fire Indication Sensor

Solid State Scientific Corporation
27-2 Wright Road
Hollis, NH 03049

Contact: Richard J. Nelson
Phone: (603) 598-1194 x130
Fax: (603) 598-1197
Email: rick@solidstatescientific.com
Website: www.solidstatescientific.com



Command: NAVAIR
Topic: N05-071

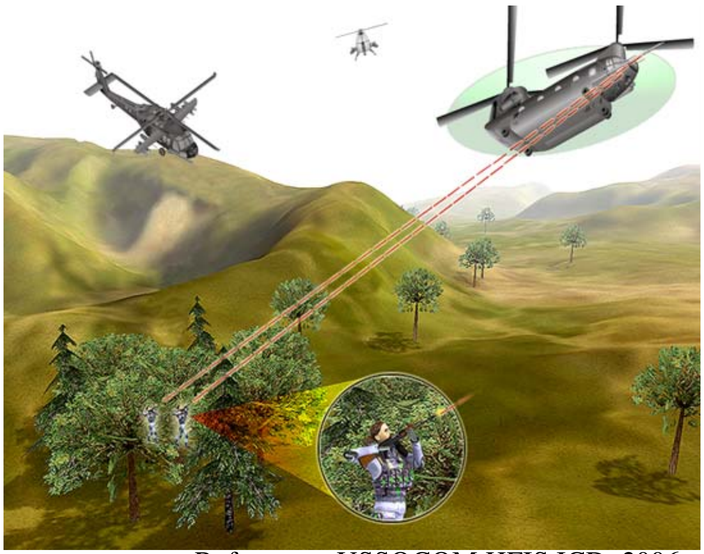
PROBLEM STATEMENT

Recent events on a national and world stage have drawn attention to the need to warn U.S. and Coalition personnel to the presence of hostile fire. Hostile fire events including Rocket-Propelled Grenades (RPG's), Anti-Aircraft Artillery (AAA) and heavy machine guns, Anti-Tank Guided Missiles (ATGM's) and even small arms fire pose an increasing risk to aircraft and ground vehicle survivability. Changing tactics and techniques by the insurgents in war zones over the last few years has led to increased effectiveness of hostile fire against Coalition targets, and customers within the U.S. Department of Defense have started to seek sensor solutions to this urgent problem.

Increasingly, helicopters are at risk to hostile fire. To date, U.S. helicopter assets downed due to hostile fire in Iraq since the beginning of operations in March 2003 total at least 14, including three AH-64 Apaches, five OH-58 Kiowas, five UH-60 Blackhawks, and one AH-1W SuperCobra. At least three other helicopters associated with the Iraq conflict have been brought down due to hostile fire. In addition, RPG's are responsible for downing at least two CH-47 Chinooks in Afghanistan over the same time period.

RPG-7

Even if the hostile fire does not down the aircraft, helicopters are a daily target for insurgent attacks. Reports from the Iraq Theater indicate that helicopter pilots are frequently unaware that their helicopters were the target of hostile fire until a post-operation inspection of the aircraft reveals evidence of flak. Unfortunately, while missile warning sensors can alert crewmembers to an attack by guided missile threats, there currently exists no hostile fire indication (HFI) sensor on U.S. aircraft for the detection and indication of RPG's, AAA, and small arms fire.



Reference: USSOCOM HFIS ICD, 2006

The need to fill the gap in aircraft protection due to hostile fire was recently underscored by an Initial Capabilities Document (ICD) issued by SOCOM (USSOCOM HFIS ICD, 03 Oct 2006). In addition, a recent Universal Urgent Needs Statement issued by the USMC emphasized the need to "develop and equip all USMC Helos, tilt rotors, and KC-130's with a comprehensive, all-environment, all-threat warning system" within 2 years (UUNS 06303UC). Finally, in a Joint Staff memorandum, dated 03 October 2006, FP FCB Chairman MajGen Howard B. Bromberg specifically advanced Solid State Scientific Corporation (SSSC) technology for HFI as "a new capability that provides…hostile fire notification to include RPG and small arms fire within the footprint of existing missile warning sensors."

In addition to aircraft, the ability to warn ground troops to the presence and location of hostile fire represents an equally important life-saving capability. To date, small arms fire and RPG/ATGM attacks are rivaled only by Improvised Explosive Devices (IED's) in effectiveness against lightly-armored vehicles such as armored personnel carriers. At present there is no widely deployed sensor to detect, declare, and locate hostile fire sources.
.

WHO CAN BENEFIT?

The HFI sensor incorporates SSSC's Multi Function Threat Detector (MFTD) technology as an adjunct HFI sensor integrated with common threat warning sensors. MFTD modules are specifically tailored to work inside the AN/AAR-47, AN/AAR-54, and AN/AAR-57 sensor heads, as well as the AN/AVR-2. In addition, the module will complement sensor suites in future threat warning and countermeasure systems, such as TADIRCM, ATIRCM, and LAIRCM programs.

UH-60 Black

Specific platforms to benefit from this timely HFI sensor technology include:

- Helicopters currently protected by missile threat warning sensors, such as the AH-1W (Navy/USMC), UH-1N (Navy/USMC), CH-53D (Navy/USMC), CH-46 (Navy/USMC), HH/SH-60 (Navy/USMC), MH-53J (USAF), MH-47D/E (USA), MH-60 (USA), AH-64D (USA), EH/UH-60 (USA), and CH-47D (USA).
- Aircraft particularly vulnerable to hostile fire attack at takeoff/landing, such as the C-130 (Navy/USMC, USAF), C-17 (USAF), and C-5 (USAF)
- Armored and light armored vehicles, such as the M1 Abrams, the M2 Bradley, and the M113 Armored Personnel Carrier.

BASELINE TECHNOLOGY

Missile threat warning (MTW) sensors for aircraft protection, such as the AN/AAR-47, AN/AAR-54, and the AN/AAR-57, use UV (ultraviolet sensors) to detect missile threats. As a result, the performance of MTW sensors suffers in certain operating environments because of unacceptable false alarm rates and limited range. Worse than these potential problems, however, is the UV sensor's inability to detect most hostile fire sources.

AN/AAR-57 CMWS

Next-generation MTW sensors are projected to include sensors that utilize the medium-wave infrared (MWIR) band for the detection of energetic threats as a way to reduce false alarm rates and extend effective sensor range. These MWIR sensors may also be effective against energetic hostile fire sources. To date, no MWIR sensors have been adopted into an airborne platform as standard equipment, but prototype next-generation MTW sensors have recently been produced that rely on costly 2-color focal plane array (FPA) technology. The current 2-color technology also requires a large cryo-cooler that greatly increases the size, power, and anticipated cost of the next-generation sensor compared to the current UV technology. In addition, the 2-color FPA technology suffers from relatively low yield manufacturing problems. Finally, the 2-color FPA technology is not easily changed to alternate color band definitions and is not scalable to additional colors were the discrimination algorithms to warrant it.

Even with advances in missile threat warning sensors, little attention has been given to the particular need to protect our aircraft and ground transport vehicles against the ever-increasing hostile fire threat. At present, therefore, there remains a significant need for a reliable, small sized, relatively inexpensive, extensible, scalable, and effective hostile fire technology.

TECHNOLOGY DESCRIPTION


HFI Sensor Integrated with AN/AAR-47

As an integrated HFI sensor, SSSC's Multi Function Threat Detector (MFTD) represents cutting-edge technology to solve the hostile fire indication problem. The primary development is a new optical detector package that can provide HFI functions using a single camera as a spectral imager. The principal technology innovation employs relatively new, commercially-available micro-lens array technology, coupled with a staring imager to simultaneously co-register multiple images on a common focal plane array. This detector has no moving parts and a small physical form factor, with the optical package requiring a volume of approximately 1 cubic centimeter. By combining a small optical element with existing camera technology, a spectral imager with multiple functions is created as a Multi Function Threat Detector (MFTD) in the same volume occupied by existing detector or detector arrays. Multiple functioning prototypes using this technology have been developed and demonstrated by SSSC for a variety of applications, including camouflage detection, threat warning, and reconnaissance.

Specific features of the current sensors include:

• Real-time detection and warning. Detection, algorithm execution, declaration, and warning to the aircrew via cockpit display happen within less than 1 second of threat launch.

• True HFI capability. The MFTD color bands and algorithms are optimized based on a library of spectral-temporal data to classify hostile fire sources by broad class while suppressing false alarms and clutter sources. Sources such as small arms fire (<0.50 cal.), AAA and large caliber fire (>0.50 cal.), RPG's and unguided rockets, and tracer rounds are detected.

• HFI location determination. The origin of the hostile fire event as determined by muzzle flash location or plume origin is determined to better than 10° in azimuth and elevation. In addition, tracking can be provided for energetic events (plumes and tracers) to provide angle of arrival information

• Compact form factor. The optics head, including micro-lens array, filters, and baffles occupy a volume on the order of one cubic centimeter; the entire MFTD module, including camera, thermo-electric cooler, camera control boards and processor board occupy a volume of a couple of cubic inches, with some flexibility in configuration to accommodate different required form factors for integration into existing systems.

• Low cost. The cost to produce the sensor is expected to be substantially smaller than currently-available multispectral sensors because of the use of a micro-lens array in place of traditional optical assemblies.

CURRENT STATE OF DEVELOPMENT

Development of the MFTD sensor to date is indicated in the following tables.

Project	*Contract*	*Program*	*Agency*	*$*	*Dates*
Micro-lens Array Hyperspectral 3-D Sensor	DAAE30-03-C-1042	Phase I SBIR	Army	$ 118,580	Jan 2003 – Jul 2003
Micro-lens Array Hyperspectral 3-D Sensor	W15QKN-04-C-1146	Phase II SBIR	Army	$ 729,947	Sep 2004 – Sep 2006
A Multi-Spectral Sensor for Missile Treat Warning	F19628-03-C-0061	Phase I SBIR Option	Air Force	$ 99,910	May 2003 – Feb 2004
A Multi-Spectral Sensor for Missile Treat Warning	FA8710-04-C-0063	Phase II SBIR	Air Force	$ 1,500,000	Mar 2004 – Mar 2007
Miniature Hyperspectral Imaging System	N00164-05-C-6075	Phase I SBIR	Navy	$ 68,534	Aug 2005 – Feb 2006
Miniature Hyperspectral Imaging System	N68335-07-C-0149	Phase II SBIR	Navy	$998,817	Apr 2007 – Apr 2009
Multi-spectral Sensors	N00421-07-D-0006	Phase III SBIR	Navy	$4,579,000	Mar 2007 – Feb 2012
Multi Function Threat Detector (MFTD)		JCTD	Joint	$11,500,000	Jan 2008 – Dec 2009

Milestone	*Completion Date*	*TRL*	*Measures of Success*
Demonstration of Micro-lens Imaging in Laboratory Setting	June 2005	4	Micro-lens optics and camera assembled; Focus and MTF measurement; Spatial mis-registration between images <0.1 pixel.
Demonstration of Field Measurements on Live Assets (with sensor in pour-filled liquid nitrogen dewar)	Mar 2006	5	System acquires targets at 2-3 km standoff; system tracks target motion (plume) within 1/10 pixel; spectral content matches established values in SW/MWIR from other instruments.
Demonstration of Field Measurements on Live Assets in Clutter Backgrounds (with sensor in pour-filled liquid nitrogen dewar)	Oct 2007	5	UAV Ground Test; System fits within UAV physical constraints; system acquires data with UAV engine running at all throttle speeds; system communicates with ground-based monitor without error.
MFTD Module Demonstration in Live Fire Field Test	Dec 2008	6	Probability of Detection (PD) and False Alarm Rate (FAR) determination
Military Utility Assessment (MUA)	Dec 2009	7	PD; FAR; System Latency; Location Accuracy

TECHNOLOGY AVAILABILITY

The Integrated HFI sensor currently represents a TRL 5 technology, with plans for continuing development as part of transition to the Navy fleet. The Development cost associated with maturation of the technology from TRL 5 to TRL 7 are approximately $11.5M, and is the development plan through the execution of an FY08 new start Joint Capability Technology Demonstration (JCTD), culminating in a Military Utility Assessment (MUA) under the direction of USSOCOM. Plans to advance the CDP sensor to TRL 8 include developing government-approved manufacturing processes and completing all qualification testing.

REFERENCES

Mr. Charles Caposell
USNUNK NAVAIR AIR-4.5T
22347 Cedar Point Rd., Unit 6, B2185
Patuxent River, MD 20670-1161
(301) 904-3502
charles.caposell@navy.mil

Maj. Andrew Shaw
OPNAV N880C11
Common Electronic Warfare
Pentagon Room 5D453
(703) 695-2489
andrew.l.shaw@navy.mil

ABOUT THE COMPANY

Solid State Scientific Corporation (SSSC) performs research for, designs, develops, and manufactures spectral-temporal sensors and high-throughput hyperspectral imaging systems for bands from the visible through the long-wave infrared. As a leader in spectral sensing technologies for US Department of Defense customers, we combine knowledge, phenomenology, hardware and software engineering acumen to create innovative and comprehensive spectral sensors from concept to prototype to production, and from source to data product to analysis. Located in Nashua, New Hampshire, SSSC has designed, built, and tested advanced prototype hyperspectral imaging systems for ISR applications in the visible/NIR, SWIR, MWIR, and LWIR bands since 1994. In addition, SSSC has pioneered simultaneous spectral-temporal sensing for real-time identification and tracking of energetic battlefield events for such applications as missile threat warning, bomb damage assessment, situational awareness, launch detection, and kill assessment. We are dedicated to improving the detection, tracking, classification, verification, declaration, and identification of military-class targets in order to enable and protect the war fighters who fight for us.