THE SPECTRE

NIGHT VISION DEVICE
&
HEAD-UP DISPLAY (HUD)

TESTING & EVALUATION

A
WHITE PAPER

by

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Spectre Camera & HUD

At center is the Objective Lens. Outboard are IR Illuminators – three on each side of the Objective Lens

SPECTRE VISION SYSTEM

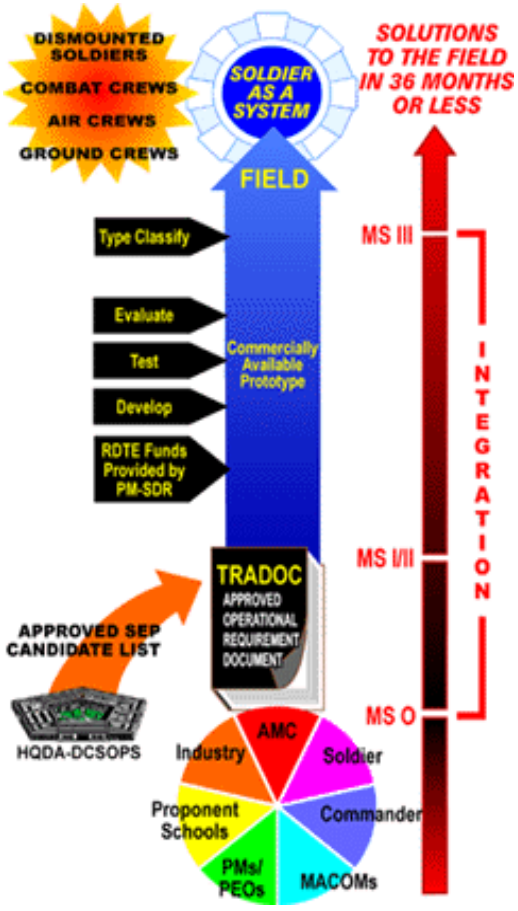
by
Gene Adcock

PURPOSE OF WHITE PAPER

The purpose of this white paper is to document and describe the ability of Tek Gear's SPECTRE VISION SYSTEM to support the US Army **Soldier Enhancement Program (SEP)** and **Objective Force Warrior (OFW)** goals for commercial-off-the-shelf (COTS) products. Specifically targeted are those goals outlined in the LETHALITY, SURVIVABILITY, COMMAND & CONTROL and MOBILITY sections of the two programs. The GOAL – to **immediately field** a COTS system that is a ninety-percent solution for the long-term OBJECTIVE FORCE WARRIOR development program. This WHITE PAPER addresses SPECTRE VISION SYSTEM as an interim solution that is immediately available to meet OFW VISION, COMMAND & CONTROL, LETHALITY goals, stated in the following paragraphs.

BACKGROUND

The goal of the US Army's Soldier Enhancement Program (SEP) is to improve the lethality, survivability, command and control, mobility, and sustainability for all Soldiers. The mission of SEP is to identify and evaluate **commercially available** individual weapons, munitions, **optics**, combat clothing, individual equipment, water supply, shelters, communication and navigational aids which can be adopted and provided to Soldiers in three years or less.



SEP has been successful because every aspect of each project is tailored to suit the need. The nature of the item determines the acquisition strategy, market survey, candidate evaluation and down select method, scope of testing, adoption decision and fielding process. Project Manager Soldier Systems and TRADOC System Manager (TSM)-Soldier are charged with responsibility for managing the SEP program for the Army. TSM-Soldier has user management responsibility and represents all soldiers in the field. PM Soldier Systems is the ASA (ALT) counterpart responsible for materiel development and fielding oversight of SEP items. Execution is performed according to commodity responsibility by Product Manager (PM) - Soldier Equipment, PM Small Arms, PM Mines, Countermine and Demolitions, PM Night Vision/Reconnaissance, Surveillance and Target Acquisition, PM Nuclear, Biological Chemical Defense Systems, and other PMs and R&D centers.

***(Background Continued -** See GOALS, Page 11)*

SPECTRE VISION SYSTEM

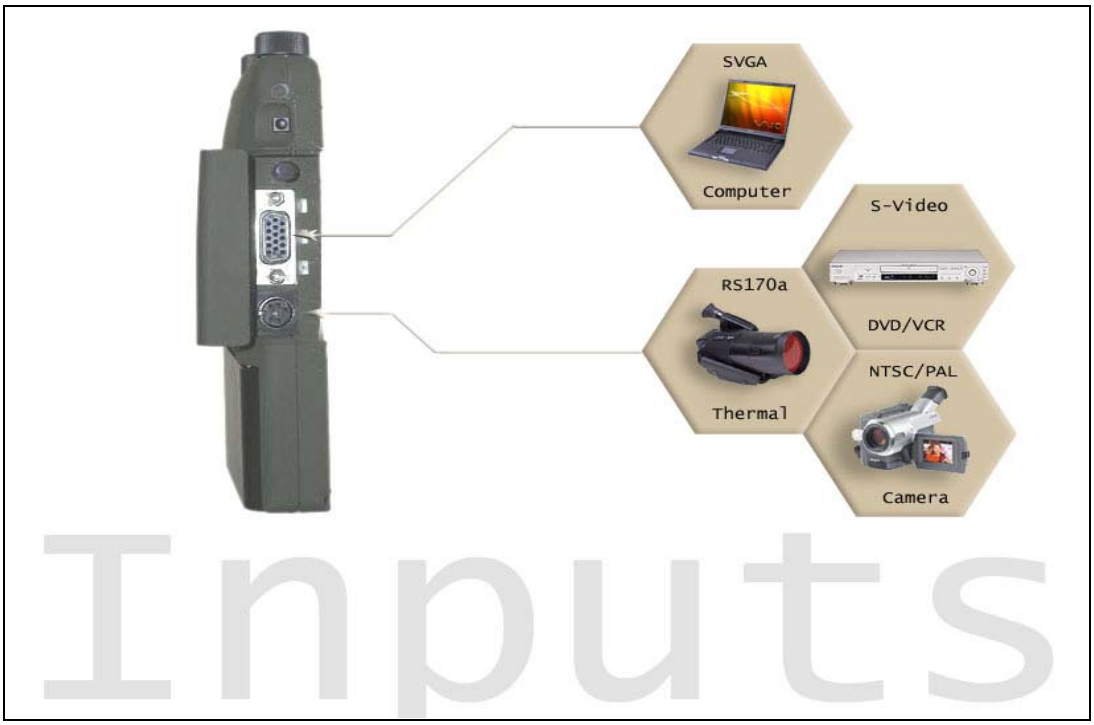
The **SPECTRE VISION SYSTEM** is a microprocessor controlled, head-up display (HUD) incorporating the newest generation electro-optic (low-light and no light) sensors. The SPECTRE has a built-in 8-step digital zoom capability that allows the user to incrementally adjust the viewed scene at 1x through 8x magnification. The ultra low-lux CCD camera and invisible 950nm LED illumination provides excellent no-light viewing capability. A narrow exit pupil eliminates facial illumination. Digital Zoom. SVGA and S-Video Auxiliary inputs allow you to switch from CCD to thermal imaging or computer video at the press of a button. Look-under design allows for an unobstructed view to the immediate area around you. Flip-up visor allows quick access to normal sight when needed. SPECTRE is compatible with most visible and invisible laser sighting and targeting devices. Finish is Dark Green Matte. The HUD is robust yet lightweight and comes with a compact pocket holder to be worn around the waist with a belt. The micro display technology delivers a high fidelity real-time, near-eye viewing experience and a 40-degree field of view. The Spectre is optimized for near field situations (<100 yards) such as building entries and close surveillance *in any lighting conditions* - ***strong sunlight, moonlight or no light at all.***

SPECTRE HEAD-UP DISPLAY (HUD) contains a light sensitive, low-lux, black and white camera that detects and processes images for direct display on two, imbedded micro-displays – one for each eye. In full-light and low-light conditions, the small (6x2.5x2.0 inch), lightweight (approximately 6 ounce) head-mounted system may be operated in the totally passive mode. In no-light conditions, six on-board infrared light-emitting diodes (IR-LED) may be activated to facilitate covert viewing. The IR-LEDs are invisible to the naked eye. The HUD features:

1. Black & white low-lux camera
2. Unity optical vision
3. Twin-SVGA micro-displays, 480,000 color pixels (1,440,000 dots)
4. Field of View of 40-degrees (Approx)
5. Operating Temperature Range of –10 to +40-degrees C
6. Interpupillary Adjustment from 60 to 70mm

The **SPECTRE CONTROL MODULE** is a small (4.1x6.1x0.98 inch), lightweight (approximately 13 ounces – including battery) microprocessor, controller and interface device. Small enough to fit into a breast pocket, the CONTROLLER also houses the Ni-MH rechargeable battery. The CONTROL MODULE contains:

1. Battery compartment
2. External power input
3. Brightness control
4. Contrast control
5. Digital Zoom control
6. 5-pin DIN connector for S-Video input
7. 15-pin D-Sub connector for SVGA input
8. Three mode indicator LED's
9. Video Mode toggle push button
10. Infrared activation push button switch
11. Indicator lamp illuminated when IR LEDs are operating.



SPECTRE CONTROL MODULE

The outboard control module may be worn on the users belt. It has manual gain and contrast adjustments; power controls and ports for data input.

SPECTRE FEATURES:

- HUD utilizes low-lux CCD to enable night vision capability.
- High resolution Liquid Crystal on Silicon (LcoS) micro displays for high quality video presentation.
- On-board adapters for Computer, Thermal Camera, Video Camera, VCR and DVD.
- Compact, lightweight design with carrying case.
- Flip-up design for quick transition to unobstructed view.
- Wide field-of-view is equivalent to a 62" screen at 6.5 feet.
- May be worn over Glasses or Goggles.
- Head mound or helmet mount.
- Optional AC Adapter operation.
- Brightness and Contrast adjustments.
- Six 950nm LED illuminators.
- Eight-power (8x) digital zoom.

SPECTRE SPECIFICATIONS	
Display Format	Night Vision
Display Type	LCoS
Video Resolution	800.0 x 600.0
Full Color Pixels	480,000.00
Aspect Ratio	4:3
Diagonal Field of View	40.0
Grayscale	256
Color Bit Depth	24
Video Interface	NTSC,PAL,S-Video,SVGA,VGA
Contrast Ratio	100:1
Luminance	60ftL
Audio	No
Microphone	No
Interface Connectors	DB15,RCA
Power Consumption	3W
Input Voltage	6VDC
Weight	107g
Dimensions	155 x 52 x 70 mm

TESTING AND RESULTS

TEST CONDITIONS: Testing was conducted on 24 August 2002, between the hours of 2030 and 2230. Illumination was estimated at 10^{-5}, the sky was completely overcast and light rain was falling. Visibility was 3 to 5 Miles. Three tests were conducted; they are described below:

a. The first test was on a 1,000 meter measured range. The range is in an open area marked with infrared (IR) beacons and IR reflective GloTape (glint tape) markers at 100 Meter (M) intervals. The range was laid out in the following sequence.
   - 1,000 M – IR-20, TacAir IR Bcn, (NSN 5855-01-460-9151)
   - 900 M – AF-2000, GloTape Flag, (NSN 8455-01-475-8887)
   - 800 M – IR-14, Phoenix IR Bcn, (NSN 5855-01-438-4588)
   - 700 M – IR-14 & AF-2000
   - 600 M – IR-14
   - 500 M – AF-2000
   - 400 M – IR-14
   - 300 M – IR-14 & AF-2000
   - 200 M – AF-2000
   - 100 M – AF-2000
   - ZERO – Operating Location

b. The second test was conducted in a heavily wooded area on the same night. During this test, there was no rain, however, the illumination and visibility was unchanged.

c. A third test was conducted inside a building to simulate a room clearing. The test was conducted at night and there was near-zero illumination inside the building.

TEST RESULTS – For comparison purposes, the author used several US Military Issue night vision devices. See ***FIELD COMPARISONS AND COMPATIBILITY TESTING*** in the following section for details. All were Generation 3, Omnibus Contract 5 (GEN III, Omni 5) image intensified devices. All operated as specified, allowing detection of man-sized targets at ranges out to 300 Meters. Infrared beacons were detected at the maximum, 1,000 Meter range. GloTape Flags (AF-2000) were detected at ranges out to 500 Meters when illuminated with the GCP-1B, 100 milli-Watt (mW) infrared laser.

Test 1. MEASURED RANGE - The TekGear Spectre was operated in tandem with the Military Issue night vision devices. Man-sized targets were passively detected at 50-Meters while operating in the 1x mode. The zoom mode (to 8x) offered a closer look at the target, but did NOT improve detection range. Switching to the active mode (operating the six IR Illumination diodes) did NOT improve detection beyond the 50 Meter target. Infrared Beacons out to 400 meters were detected. Infrared reflections from GloTape Flags were detected out to 200 Meters.

Test 2. HEAVILY WOODED AREA - The TekGear Spectre was operated in a heavily wooded area. In the passive mode, the Spectre was virtually blind. In the active mode (operating the six IR Illumination diodes) detection range was excellent out to 15 Meters. The zoom mode (to 8x) offered a better view of targets within the detection range, but did not increase detection range.

Test 3. INSIDE BUILDING – The Tek Gear Spectre was operated inside a building to simulate a military action called ***Room Clearing***. Room Clearing is a military action where combat teams systematically work through a target building, searching (clearing) each room of suspected enemy personnel. The Spectre was blind to targets in the passive mode. However, in the active mode (operating the six IR Illumination diodes), the Spectre performed well. Man-size targets were easily detected at maximum (15 M) range. Targets were clear and facial detection (recognition) was not a problem. The zoom mode (to 8x) offered a better view of targets within the detection range, but did not increase detection range.

CONCLUSIONS – The following are conclusions drawn by the author, based on the foregoing test results.

- The Spectre is **NOT** a candidate for US Military Combatants operating in a dark field environment.
- The Spectre **may be** useful for US Military Support Personnel providing behind-the-lines support, in dark environments where light discipline is necessary.
- The Spectre **may be** useful for US Military Combatants operating in dark, close quarters; e.g. caves and buildings. However, for these operations, it is recommended that an outboard detection device; i.e., weapon mounted thermal detector be connected to the Spectre HUD.
- The Spectre's **greatest attribute** is its ability to fuse sensor technologies, offering a user the ability to observe targets through a variety of sensing devices. For example, the user may elect to connect his thermal (IR) weapon sight to the Specter HUD. The user would have the ability to view a scene through Specter's Low-Light sensors or select the IR sensor. Additionally, in this IR weapon mounted scenario, the user would have the ability to point (and see) around and over obstructions. Thus reducing exposure to hostile targeting.

FIELD COMPARISONS AND COMPATIBILITY TESTING

COMPARISONS - The Spectre was tested along side the AN/PVS-7D (NSN 5855-01-461-8169) and the AN/PVS-14 (NSN 5855-01-494-5916), both Generation III, Omnibus 5 (GEN III, Omni-5) image intensified night vision systems. Both are used by the US Military and represent the most common night vision goggle (NVG) systems in use by dismounted forces. These NVG may be head mounted, helmet mounted or hand-held and provide only night viewing capability. Unlike the Spectre, there is no on-board facilities for input/output of data and they are not usable in daylight. A head-up display capability exists only when fitted with the optional Magnetic Compass Module, A3187430. Magnification attained with the fitting of optional three- or five-power afocal magnifier lens assemblies.

DETECTION RANGES IN METERS – MAN ON GREEN GRASS (TYPICAL)

AN/PVS-7D	Quarter moon – 417	Starlight – 297	Cloud Cover Starlight – 163
AN/PVS-14	Quarter moon – 417	Starlight – 297	Cloud Cover Starlight – 163

Visit http://www.nvec-night-vision.com/products/products.asp?category=1 for more detail.

COMPATIBILITY - The Spectre was tested with infrared (IR) beacons, pointers, illuminators and reflectors (GloTape) operating in the 830-900 nanometer (nm) wavelengths. The following is a listing of those systems tested for compatibility.

- **ACP-2A**, Air Commander's Pointer, 5855-01-420-0814, 100mW, Adjustable Beam Diameter
- **GCP-1B**, Ground Commander's Pointer, 5855-01-420-0851, 100mW, Adjustable Beam Diameter
- **GCP-2A**, CCT-Aimer, 5855-01-420-0814, 100mW, Adjustable Beam Diameter
- **AF-2000, GloTape, American Flag, IR-Reflective, 8455-01-475-8887 (2"x3" Glint Tape illuminated with GCP-1B)**
- **IR-20**, TacAir Beacon, 5855-01-460-9151, 19-IR LED, Flashing Beacon
- **IR-14**, Phoenix Jr., 5855-01-438-4588, 3-IR LED, Flashing Beacon
- **IR-15**, Phoenix, 5855-01-396-8734, 3-IR LED, Code-able Flash Beacon

BACKGROUND (GOALS) – Continued from Page 3

Each year nearly 125 proposals are received and reviewed for suitable solutions to keep up with ever-changing technologies and new and improved ways to equip and maintain our forces. “New Start” proposals that match up with user deficiencies are presented at the Annual PEO/TRADOC SEP Review and compete for funding in the upcoming fiscal year.

- **Lethality:** Commercial and Non-Developmental Items (NDI) can enhance a Soldier’s capability to detect, acquire, identify, locate, engage, and defeat threat soldiers and their equipment at greater ranges, and with greater accuracy, in all visibility conditions.
- **Survivability:** SEP items can increase the Soldier’s self-protection against threat weapon effects and environmental conditions through weight/bulk reduction, signature reduction, and improved protection.
- **Command and Control:** Commercial-Off-The-Shelf items are readily available to increase the Soldier’s effectiveness to direct, coordinate, and control personnel, weapons, equipment, information, and procedures through improved situational awareness and accuracy and timeliness of information.
- **Mobility:** SEP items enhance Soldier deployment and movement on the battlefield while conducting missions by providing them with lighter weight, logistically supportable equipment and load carrying capability.
- **Sustainment:** SEP supports the capability of soldiers to sustain themselves while operating in a tactical environment. Sustaining soldiers means supplying them with those items fundamental to sustained operations critical to their overall effectiveness and performance, such as water, shelters, and ancillary support equipment.

(Data from: https://www.pmsoldiersystems.army.mil)

ARMY'S LONG-TERM OFW GOAL

Modernizing the Warrior through Army Transformation:

Objective Force Warrior (OFW) is the Army's flagship Science and Technology initiative to develop and demonstrate revolutionary capabilities for Objective Force soldier systems. An integrated system of systems approach is being employed to support the Army transformation to a soldier-centric force. The Objective Force Warrior is a major pillar of the Objective Force strategy, complementing the Future Combat Systems (FCS) program.
OFW notional concepts seek to create a lightweight, overwhelmingly lethal, fully integrated individual combat system, including weapon, head-to-toe individual protection, netted communications, soldier worn power sources, and enhanced human performance. The program is aimed at providing unsurpassed individual & squad lethality, survivability, communications, and responsiveness — a formidable warrior in an invincible team. OFW will also be developed for full integration with FCS.

OBJECTIVE FORCE WARRIOR:
A Formidable Warrior in an Invincible Team, able to See First, Understand First, Act First, & Finish Decisively.

- **LETHALITY VISION:** OFW family of lightweight weapons with advanced fire control, optimized for urban combat, and synchronized direct and indirect fires from Future Combat System.
- **SURVIVABILITY VISION -**Ultra-Lightweight, Low Bulk, Multi-Functional, Full Spectrum Protective Combat Ensemble.
- **SENSORS & COMMUNICATIONS (C4ISR) VISION** - Netted OFW small unit/teams with robust team communications, state-of-the-art distributed and fused sensors, organic tactical intelligence collection assets, enhanced situational understanding, embedded training, on-the-move planning, and linkage to other force assets.
- **POWER VISION** – A 72-hour continuous autonomous team operations, high density, low weight/volume, self-generating/re-generating, reliable, safe power source/system.
- **MOBILITY, SUSTAINABILTY and HUMAN PERFORMANCE VISION** - Unconstrained vertical and lateral movement at full up combat/assault capability during mission execution. Optimized cognitive and physical utility, on-board physiological/medical sensor suite with enhanced prompt casualty care.

(Data from http://www.natick.army.mil/soldier

REFERENCES

1. **ELECTRO-OPTICAL SURVEILLANCE** (Vol. 3, Security Source Library) by Gene Adcock. CCS Security Publishing, Ltd. (ISBN 1-884674-03-08), a 700-page reference book covering almost every aspect of Night Vision systems and technology, both image intensification and thermal imagery. From World War II to Operation Desert Storm, the history of Night Vision equipment development is detailed in illustrations and diagrams and carefully spelled out. The physics of Night Vision Equipment (NVE) is provided along with the principles of optics, and the differences between image intensification and thermal imaging demonstrated along with the systems that were developed using the different generations as they became available. The book discusses the application of such imagery for both military and civilian use. There are few, if any books of this depth available outside of individual service technical manuals produced for and by the military establishments. The author, Gene Adcock brings to the creation of this book, a broad spectrum of practical experience both in the development of new and innovative products as well as the sale of those products for the many military and civilian applications of surveillance equipment. Gene has been a consistent contributor to the SO/LIC Community and to the SO/LIC Division of NDIA. (Reprinted with Permission, National Defense Industrial Association, http://www.ndia.org)
2. https://www.pmsoldiersystems.army.mil
3. http://www.natick.army.mil/soldier
4. http://www.nvec-night-vision.com
5. http://www.opsd.nos.noaa.gov
6. http://www.tekgear.com
7. http://www.tekgear.com/documentation/manual/0066_manual.pdf

MOON PHASES FOR AUGUST 2002 (NORTHERN HEMISPHERE)

p	m	d	h : m
	Aug	1	10:22
N	Aug	6	07:--
	Aug	8	19:15
P	Aug	10	23:--
E	Aug	12	12:--
	Aug	15	10:12
S	Aug	19	01:--
	Aug	22	22:29
E	Aug	26	08:--
A	Aug	26	18:--
	Aug	31	02:31

p - phase m - month d - day h : m - hour : minute

THE AUTHOR

Gene Adcock, until April 2002, was Vice President, Night Vision Equipment Company (NVEC), Inc., Emmaus, PA. Now President and founder of TACTICAL VISION, Inc.; he is also the Senior Military Consultant to NVEC and Special Operations Liaison for Tactical & Survival Specialties, Inc. (TSSI), Harrisonburg, VA. He holds Masters and Bachelors Degrees in Business and Economics. He is the Author of ***ELECTRO-OPTICAL SURVEILLANCE****, a* Night Vision Reference Encyclopedia and numerous articles published in trade magazines.

A retired US Air Force Combat Controller with more than eighteen years on jump status; he logged more than 300 static line and 100 HALO parachute jumps. During the period 1965-1971, he served four combat tours in Southeast Asia; one in Vietnam and three with an Air Commando group in Northern Laos supporting air operations against the Ho Chi Minh trail. His combat awards and decorations include USAF Aircrew Badge, Master Parachutist Badge with Combat Star, two Bronze Star Medals, six Air Medals, six Air Force Outstanding Unit Awards with Combat-V and two Meritorious Service Medals.

After retiring as a Chief Master Sergeant, he became actively involved in the development, marketing and sales of specialty devices for survival, escape, rescue, evasion, drop/landing zone operations and night tactical operations.

TEK GEAR, INC.

Tek Gear develops, manufactures and represents the latest innovations in head mounted, hand held and custom display solutions. With Tek Gear if you want it, need it or imagine it - they can deliver.

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