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**CATADIOPTRIC OMNI-DIRECTIONAL SYSTEM FOR M1A2 ABRAMS
(360-DEGREE CAMERA SYSTEM)**

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Armaments Engineering & Technology Center

Picatinny Arsenal, New Jersey



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INTRODUCTION

The Catadioptric Omni-Directional System (fig. 1) was developed by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) Acoustic and Network Sensors Office, Picatinny Arsenal, New Jersey to demonstrate existing technologies that could increase situational awareness for the M1A2 Abrams' crew. The project required a rapid and easily incorporated solution that could attach to the tank without permanent modification and at low cost. On 23 February 2005, the completed system was demonstrated to the PM Abrams' Tank Urban Survivability Kit (TUSK) Program Manager.

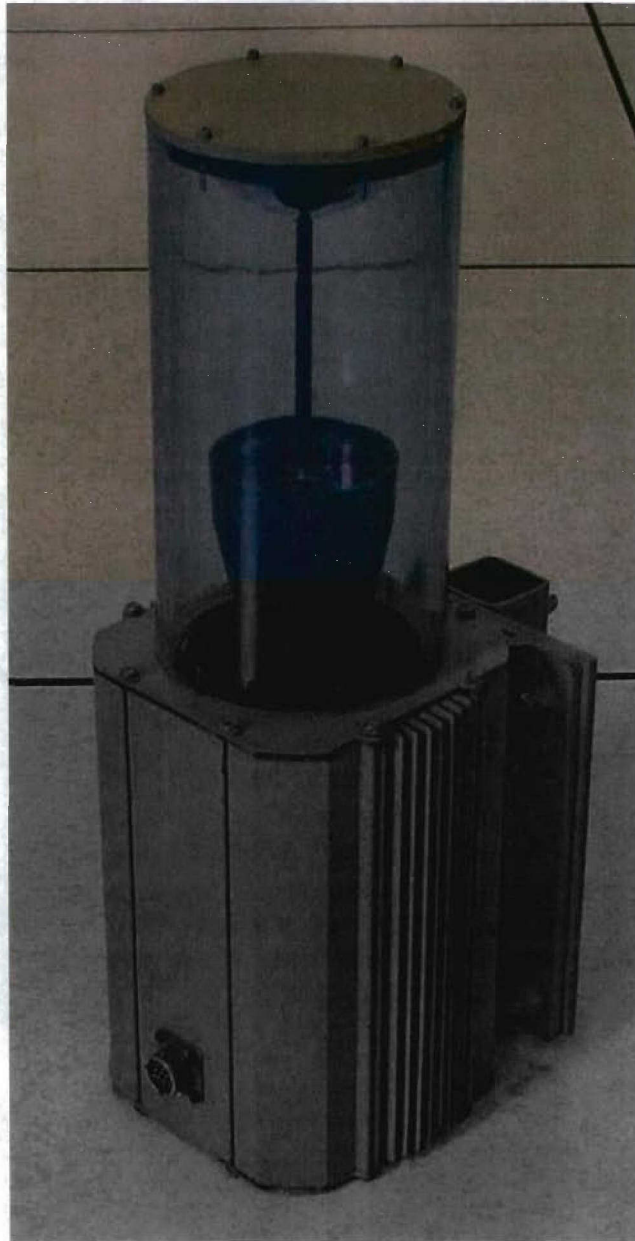


Figure 1
Omni-directional camera

BACKGROUND

The M1 series of tanks and other armored vehicles inherently provide limited visibility while the hatches are closed and lack any visibility immediately around the vehicle. Additionally, hatches, when opened, tend to impede observation to the rear of the tank commander (TC) and loader (LDR) while they are at the proper name tag defilade. Recently, an incident occurred in Iraq where an insurgent was able to mount a tank from the rear unobserved and kill the TC and LDR. This system will assist the crew in 360-deg surveillance when hatches are opened or closed.

The technology is commercial off-the-shelf (COTS) and readily available. The system mounts on the turret behind and between the two hatches with two flat panel displays in the turret and an optional flat panel display for the driver. The driver's panel is connected by a cable between the turret and hull (no slip ring interface) and has a quick disconnect that functions when the turret is traversed beyond a set limit. The driver's station wasn't fully developed/ demonstrated, since a driver's station did not interest PM Abrams. The LDR and TC have flat panel displays (figs. 1 and 2) that are mounted with heavy duty Velcro for easy removal. These three panel locations allow for multiple redundancies, and take advantage of the limited role that a driver may have while conducting security over-watch of a traffic control point (TCP).

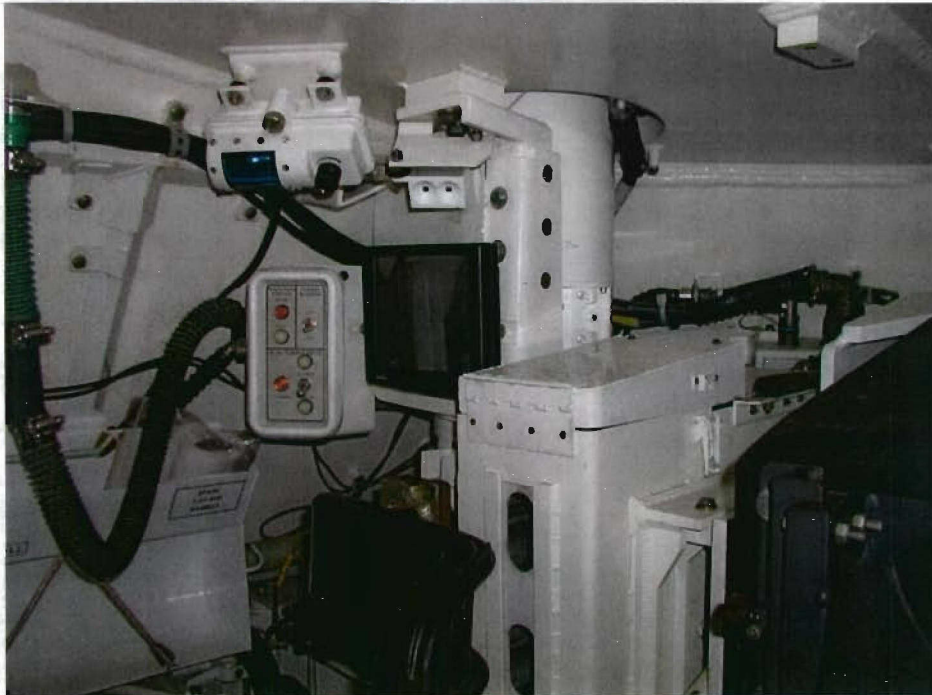


Figure 2
Loader's display panel



Figure 3
Tank Commander's display panel

The system was displayed and demonstrated in the ARDEC display area at the AUSA Conference, February 2005, Tampa, Florida.

M1A2 ABRAM TANK CREW STATION SITUATION AWARENESS SYSTEM COST PROPOSAL

Organization: U.S. Army ARDEC, Armaments Engineering & Technology Center, Fuze and Precision Armaments Technology, Acoustic and Networked Sensors (AMSRD-AAR-AEP-A)

Total Dollar Amount for this Proposal: \$50,000*

Direct Material Costs:

Hardware (Camera: IQINVISION Hi Speed Varifocal Kit, Pentium Mobil 900 MHz, casings, circuit boards)	7,000
Software	3,000
Update Processor (Pentium Mobil 1.6 GHz)	3,000
Network Equipment	1,500
Total Direct Material Costs	\$14,000

*All monies mentioned in this report are from FY05.

REQUIREMENTS

Initial Requirements

- 360-deg capability
- +/- 30 deg above and below horizontal plane
- No permanent modification to the tank
- Able to withstand a rock
- Cheap

Updated Requirements

1. General Dynamics (GD) Land Systems, as Lead Systems Integrator for TUSK, was tasked by the PM to release the Periscope Request For Proposal in 10 days.
2. 360-deg periscope requirements:
 - Day camera with illumination for night use
 - +/- 30 deg vertical Field of View (FOV)
 - 180 deg horizontal FOV
 - ONLY the Loader's Display is required
 - Externally mounted components must withstand being struck by a thrown rock
 - Must withstand shock/vibration when main gun is fired
3. Cost less than \$15K.

PROCESS

System design, while meeting the requirements, was governed by location of the camera, vehicle space constraints, and power availability. The camera location needed to be situated such that it did not interfere with the crosswind sensor, the M2 .50 cal machine gun, or loader's M240 7.62-mm machine gun. To quickly install the camera, a portable stand made from 1 in. square stock and attached by heavy duty magnets between the LDR's and TC's hatches was used. PM Abrams representatives were consulted to determine the best placement for the camera to minimize crosswind sensor interference. A simple COTS aluminum casing and a clear Lexan tube housed the camera and lenses. It was attached to the stand by two thumb screws. Further testing is required to determine whether this camera with protective casing could withstand the over-pressure from the main gun firing.

A benefit of this location is that the power/transmission cable could easily be run through the same ports as the grenade launcher wiring harness. In order to minimize cables, an internet cable capable of also transmitting power was chosen. The team identified an available auxiliary power port on the SINCGARS radio mount that supplied the correct power levels, and a plug was fabricated and connected to the system.

The user interface used the same power source as the camera. The project required a user interface that wouldn't interfere with normal turret operations. Two locations in the turret were identified: one on the wall to the TC's right and one on the Commander's Independent Thermal Viewer (CITV) housing for the LDR's position. The amount of space is very limited, so touch sensitive 8-in. flat panel monitors were selected. Heavy duty Velcro would be used to mount the monitors inside the turret, but permission to glue Velcro to the inside of the M1A2 has not yet been received.

The driver position concept required information transfer between turret and hull. The slip ring transmits data between the hull and turret, but was not a practical solution for this system. It was decided that the most efficient method would be to have a cable run through the turret basket with a quick disconnect that would function if the turret traversed beyond a certain limit. The cable would be anchored to the turret basket and to a hard point in the driver's compartment. This way only the cable would be under tension during the moment the quick release capability functioned. The storage place for the monitor was on the ceiling where the headrest folds up. The initial assessment was that the monitor held in a metal bracket would be able to withstand the pressure applied by a stowed headrest. The mounting bracket would enable a support arm to swivel out from the right side (above the night-sight stowage) and the monitor would quickly mount to it. This would enable the driver to have hands-free access to the system during movement (backing up) or during stationary TCP operations. The driver's station wasn't developed. Factors contributing to this were funding (custom made bracket), ineffective non-permanent adhesive for the mounting bracket, and lack of interest by PM Abrams.

The system's central processing unit (CPU) was customized in order to minimize its footprint. It used the top of the line chip at that time. The CPU plugged into the auxiliary power port from the SINCGARS mounting base. Due to its compact size, a spot was identified forward of the CITV housing and the coaxial cable box, where it could sit out of the way. The initial processing, combined with the camera, produced about a 2 sec lag between reality and output on the screen. This was reduced to about 0.5 sec by installing a newly released chip. To be able to operate this system in real time would require purchasing a more expensive camera.

The demonstration camera was a 2.0 mega-pixel camera that captured 30 frames per second. The mega-pixel quality of the camera exceeded the 8-in. monitor's capability to display. The monitor displayed approximately a 0.5 mega-pixel picture. The camera with the catadioptric lens produces a 'donut' picture of its surroundings. Software developed by Remote Reality was used to unwrap the image. The monitor screen was split so that the top half displayed the front 180 deg (relative to the turret) and the bottom showed the rear 180 deg. The FOV, as demonstrated, was 15 deg above horizon and 70 deg below. The distance at which a target was lost from view as it approached the vehicle was not measured.

To increase the effectiveness of the system, a tracking program developed by Remote Reality was used. This software recognized movement and created colored boxes around all moving objects. The software was capable of recognizing environmental movement (flying flag, moving wires, etc.) and canceling it out from the picture so that it focused only on people and vehicles. The user is able to define the area in the FOV that the software focuses on. During the demonstration, the software identified movement out to around 100 m. A simple system improvement would be to incorporate an audible warning sound as the tracking software engages.

ISSUES

Camera

The catadioptric camera can not zoom in optically, but software allows it to digitally zoom in on a selected area. The output can be manipulated to achieve the desired display. The screen display was chosen to be split in two; the top oriented to the front relative to the turret and the bottom to the rear. An alternate display was set up for the PM Abrams/GD demonstration that had the top half oriented to the front and the bottom split into three sections. The current camera's processing speed induces lag, so the displayed picture is jumpy and about 1 to 2 sec behind real time.

Display Screen

The small display screen limits picture quality. The 8-in. model was selected because of the limited available space inside the M1A2. The user can choose additional displays, depending on requirements.

CPU

Custom made and later upgraded to top of the line processing chip. This chip reduced lag to about 0.5 sec. Its small size enabled stowing it in out-of-the-way open places.

RECOMMENDATIONS

At this time, no additional funding for the Catadioptric Omni-Directional System is recommended in support of the Tank Urban Survivability Kit.

Materials for the complete system cost \$14K. Labor was paid by overhead and not figured into the cost of the system. PM Abrams was surprised at the maturity of the system and liked the tracking software, but felt that other industry systems performed better. General Dynamics Land Systems witnessed the demonstration and know the capabilities of the system, but did not express too much interest. They are releasing an RFP in the near future, and the U.S. Army Armament Research, Development and Engineering Center was not included on the evaluation board.

The Lieutenant Colonel for PM Crew Served Weapons mentioned the potential to incorporate the camera system into the Common Remote Operated Weapons Station, but there currently is no requirement for it.

ACRONYMS AND ABBREVIATIONS

ARDEC	U.S. Army Armament Research, Development and Engineering Center
CITV	Commander's independent thermal viewer
COTS	Commercial off-the-shelf
CPU	Central processing unit
GD	General Dynamics
FOV	Field of view
LDR	Loader
TC	Tank Commander
TCP	Traffic control point
TUSK	Tank urban survivability kit

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