Improved Mobility and Operational Performance through Autonomous Technologies - Army Technology Objective

TARDEC Intelligent Ground Systems

360° Situational Awareness/ Indirect Vision Driving Team

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **01 JUN 2011**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**

4. TITLE AND SUBTITLE **Improved Mobility and Operational Performance through Autonomous Technology - Army Technology Objective**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA**	8. PERFORMING ORGANIZATION REPORT NUMBER **21982**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) **US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA**	10. SPONSOR/MONITOR'S ACRONYM(S) **TACOM/TARDEC/RDECOM** 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**SAR**	**17**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

IMOPAT ATO

360/90 Day/Night
Near-Field Sensor Coverage

Advanced Crew Stations

Integration Platform

Occupant Monitoring

Goals

Develop *Indirect Vision* and *Drive by Wire* Systems that Provide Electro-Optic Indirect Vision Based **Local Situational Awareness** and **Mobility Capabilities** At or Above the Performance Levels of Direct Vision Mechanical Drive Systems and to Enhance High-Definition Cognition Technologies to Dynamically Manage Workload to Increase Operational Performance on Future Platforms.

Objective

TARDEC-Led IMOPAT ATO Contains CERDEC-NVESD, ARL-HRED, and NSRDEC as Joint Partners to Mature *Visual Sensor Suites*, *Human Integration*, and *Assisted Mobility Technologies* in Three Phases of Evolution:

– Baseline: Establish Initial *Indirect Vision Driving (IVD)* and *360-Degree Local Situational Awareness (LSA)* Capabilities.

– Enhanced: Increase IVD and LSA Capabilities.

– Advanced: Integrated State-of-the-Art IVD and LSA System that Provides “Secure Mobility Capability”.

IMOPAT ATO

- To Transition 360 SA Systems to the Field, Operationally Relevant Requirements Must Be Developed
  - Systems must also be affordable and sustainable

- 360 SA Requirements Must Be Based Upon Evaluation Parameters in the Following Areas:
  - Vehicle-Mounted Visual Sensors
  - Data Transmission Systems
  - In-Vehicle Displays
  - Intelligent Cuing Technologies
  - Human Factors Considerations

IMOPAT ATO

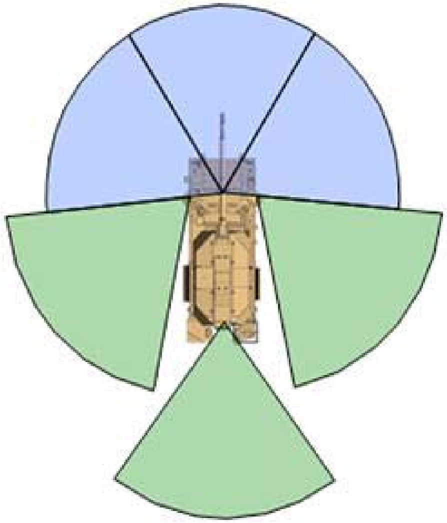
- IMOPAT ATO Established to Develop Cost-Effective 360 SA System for Ground Combat Vehicle (GCV)
  - **Objective**: Limit Per-Unit Cost to Ease Transition into the Field
  - Included Capabilities:
    - High-Resolution Sensors and Displays
    - Advanced Warfighter-Machine Interfaces (WMI)
    - Automated Control and Threat Cuing Algorithms
    - Occupant Workload Management Systems

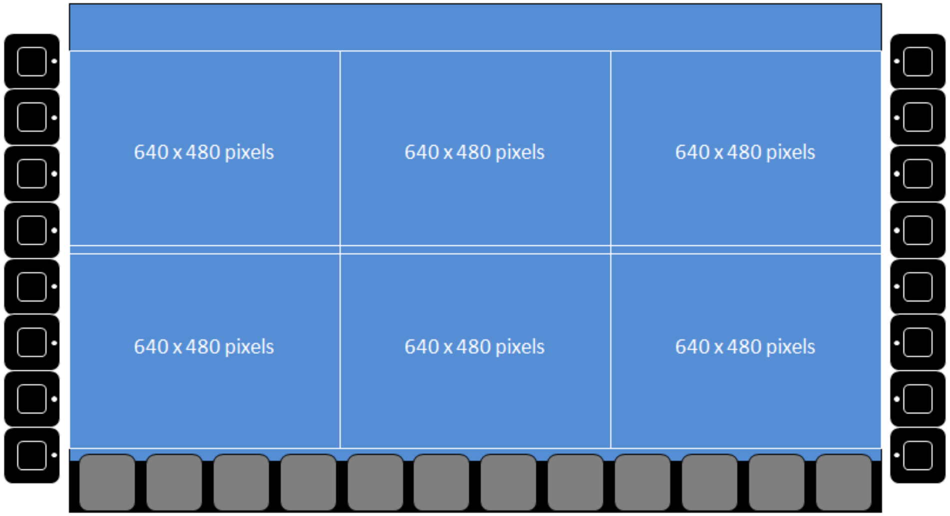
Experimental Platforms

Fielded Systems

IMOPAT ATO

- 360 SA Systems Upon Other Vehicle Platforms Have Similar *Designs, Characteristics*, and *Requirements*
  - Yet Generally, Development Efforts Are **Largely Independent**
- Years of Trial and Experimentation Have Promoted *Standard 360 SA Design Practices*
  - Increased Collaboration Between Technical and Military Operational Experts Now Required to Develop Standard Requirements

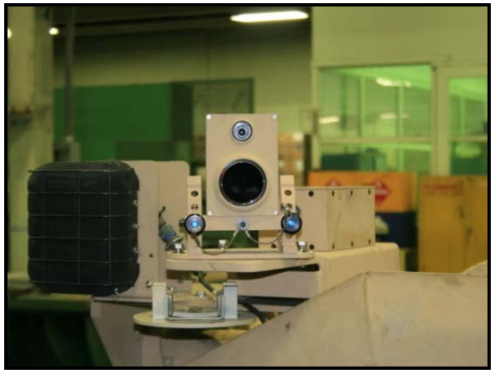


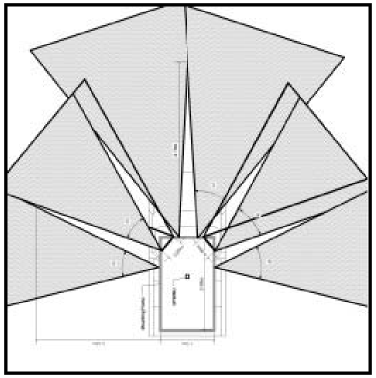


Vehicle-Mounted Visual Sensors

- Visual Sensors Are Fundamental Components of 360 SA
  - *Detect*, *Recognize*, and *Identify* Threats from Safe Distance
  - Used to Augment Other Sensors Upon Vehicle

- A Single Sensor Cannot Tend to Sometimes-Conflicting Requirements of Complete 360 SA System
  - Thus, Vehicle-Mounted 360 SA Systems Are *Designed in Layers* to Account for Conflicting Requirements





Vehicle-Mounted Visual Sensors

- **Detection Layer**
  - Set of Fixed, Wide FOV Sensors That Offer Simultaneous 360-Degree Coverage of Surrounding Environment
- **Interrogation Layer**
  - Set of High-Resolution, Narrow FOV Sensors That Interrogate Threats Discovered in Detection Layer
- **Broad-Area SA Layer**
  - Video Communication with Unmanned Aerial Systems (UASs), Unmanned Ground Vehicles (UGVs), and Other Assets

Vehicle-Mounted Visual Sensors

- ***Simultaneous Field of View***: The FOV That a 360 SA System Concurrently Obtains Across All Sensors Upon Vehicle

- ***Sensor Field of View***: FOV of Single Sensor in 360 SA System
  - Fundamental Trade-Off Between *Sensor FOV* and *Range Performance*

- ***Range Performance***: The Maximum Distance of a Target from Imager At Which an Observer Can Conduct Discrimination Task

- ***Ground Intercept***: The Nearest Intercept of a Sensor's Cone of Vision with the Ground

Data Transmission Systems

- Data Transmission Systems Transfer Information from One Component of 360 SA System to Another
  - Example: *Visual Sensor* to *In-Vehicle Display*

- Analog Systems Provide Acceptable *Reliability*, *Ease of Integration*, and *Latency*
  - Drawbacks: Limited *Resolution* & *Video Processing* Capabilities

Data Transmission Systems

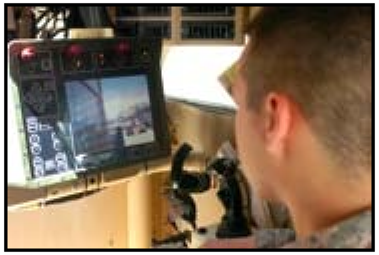
- 360 SA Systems Aim to Adopt Digital Video Architectures
  - New Limitations: Greater *Bandwidth* and *Latency* Constraints

- Despite Limitations, Digital Video Offers Opportunities to Provide Advanced Capabilities:
  - Discriminate Threats via Intelligent Cuing Technologies
  - Identify Potential Improvised Explosive Devices
  - Record Visual Sensor Information for Future Analysis
  - Share Video Information with Other Battlefield Resources

In-Vehicle Displays

- In-Vehicle Displays Are Vital Components of 360 SA
  - Display Warfighter-Machine Interface to Vehicle Occupants
  - Provide Interface to 360 SA Video Sensor Imagery
  - Provide Interface to Vehicle Diagnostic and Management Functions

- Display Resolution Must Match or Exceed Sensor Resolutions
  - Advanced Sensors Cannot Be Fully Utilized Without Adequate Displays



In-Vehicle Displays

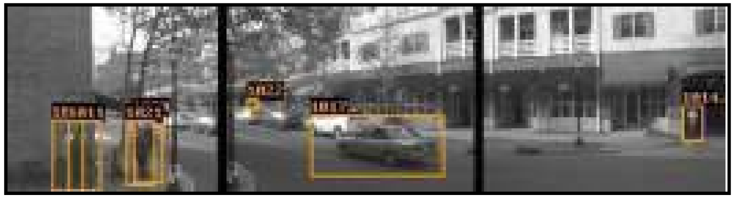
- ***Screen Size***: The Physical Dimensions of the In-Vehicle Display
  - Constrains the Capabilities of the Warfighter-Machine Interface

- ***Screen Resolution***: The Number of Pixels within the Vertical and Horizontal Components of the In-Vehicle Display
  - Must At Least Match the Resolution of Vehicle-Mounted Sensors

- ***Brightness and Contrast***: Must Be Chosen to Maximize Warfighter Ability to Visualize Sensor Imagery
  - Brightness: The Maximum Luminance of In-Vehicle Display
  - Contrast: The Ratio of Brightest to Darkest Color That Display May Produce

Intelligent Cuing Technologies

- Intelligent Cuing Technologies Aim to Minimize Cognitive Load Upon Warfighters:
  - Draw Warfighters’ Attention to Potential Enemy Combatants, Improvised Explosive Devices, and Other Battlefield Threats
  - Classify the *Threat Level* of Detected Objects
  - Identify Road Edges or Traversable Off-Road Terrains



Intelligent Cuing Technologies

- ***Probability of Correct Detection***: The Probability That a System Correctly Detects the Event for Which It Was Designed
  - *Perfect Detection Unrealistic*
  - Yet, Cannot Be So Low As to Render System **Ineffective**

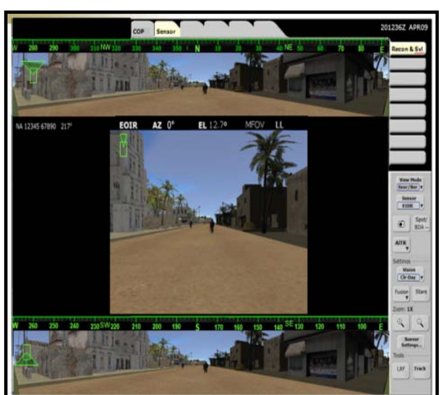
- ***False Alarm Rate***: The Rate at Which a System Misrepresents a Non-Event as an Event for Which It Was Designed
  - *Perfect False Alarm Rate Unrealistic*
  - Yet, Cannot Be So High As to Render System **Unreliable**

- ***Computational Load***: The Computational Capabilities Required to Drive Intelligent Cuing Algorithm
  - Must Minimize Burden on *Support Systems* and Maintain *Latency Requirements*

Human Factors Considerations

- Cognitive Load Must Be Minimized through Effective WMIs
  - WMIs Provide Access to 360 SA Capabilities
  - Must Be *Simple to Use*

- Human Factors Research Has Brought About Development of Standard Metrics to Assess WMI Effectiveness
  - Helps to Ascertain the *Ease* and *Quickness* with Which the Warfighter Interacts with 360 SA System



Human Factors Considerations

- ***Probability of Correct Identification***: Represent the User's Ability to Correctly Identify a Target in a Given Environment
  - Constraints: Environmental Stressors, Visual Display Characteristics, Decision Aids, and User Training Modules

- ***Glance Time***: The Time a User Needs to Visually Sample a Scene through the WMI

- ***Movement Time***: The Time a User Needs to Manipulate a Control Within the WMI

- ***Reaction Time***: The Time Elapsed Between the Onset of Warfighter Stimulus and His Response

Questions?