Active Defense Systems (ADS) Program – Formerly Integrated Army Active Protection System Program (IAAPS)

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SUMMARY

United Defense's Advanced Development Center was selected as the prime contractor for a program currently known as the Integrated Army Active Protection System in 1997. Along with our teammates, BAE Systems and Northrop Grumman Space Technology, United Defense performed a series of technology investigations, conducted simulation-supported concept development and down-selected to a best value integrated survivability suite (ISS) consisting of an optimal mix of armor, electronic warfare sensors, processors and soft kill countermeasure, and hard kill active protection in November of 1998. At that point the program transitioned to a development and demonstration phase in which the United Defense led team designed and fabricated the selected survivability suite (ISS), integrated the ISS onto a customer-selected EMD version BFVA3 test-bed and conducted live threat defeat testing. Static testing against a wide array of live threats successfully concluded in September of 2002. By December of 02, the IAAPS team was back at the range with the test-bed reconfigured for on-the-move (OTM) testing. Successful OTM defeats were conducted with the soft kill countermeasure in January of 2003, with hard kill defeats conducted in February through May of 2003. This presentation briefly describes the structure of the program, provides an overview of the sensor and countermeasure architecture, highlighting the ability to support plug and play implementation of threat sensors and describes the results of the highly successful static and moving test programs. Videos of threat defeats from the static and moving platform will be shown.

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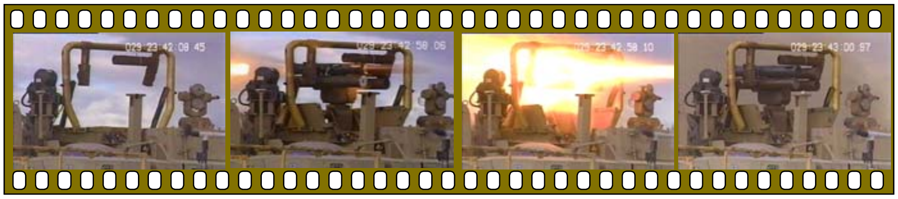
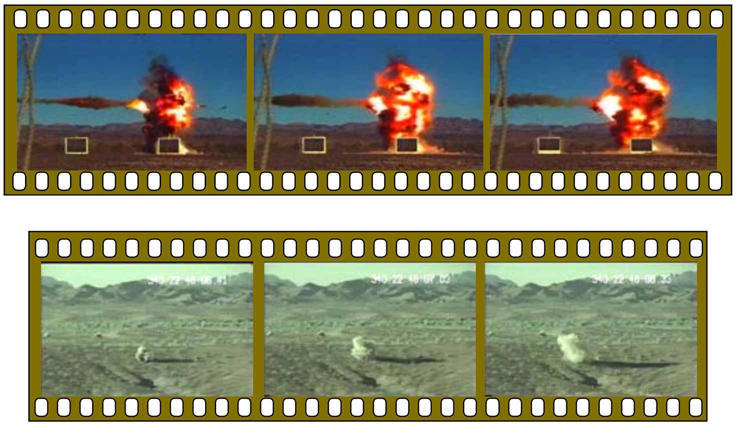


AP Countermeasure Launch



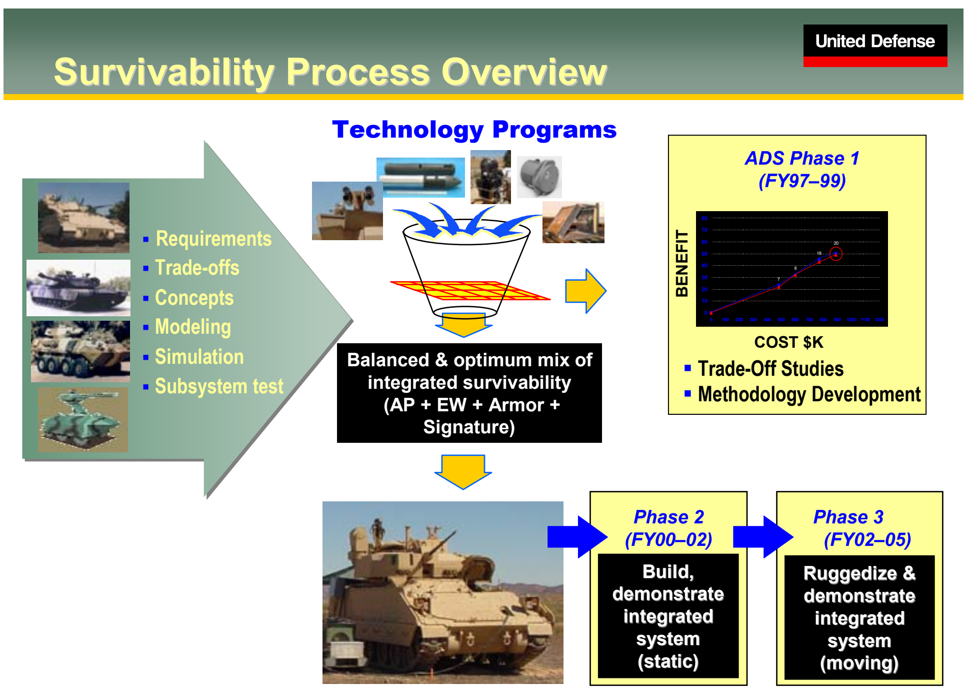
AP Intercept with Threat and EW Defeat of Threat

1.0 INTRODUCTION

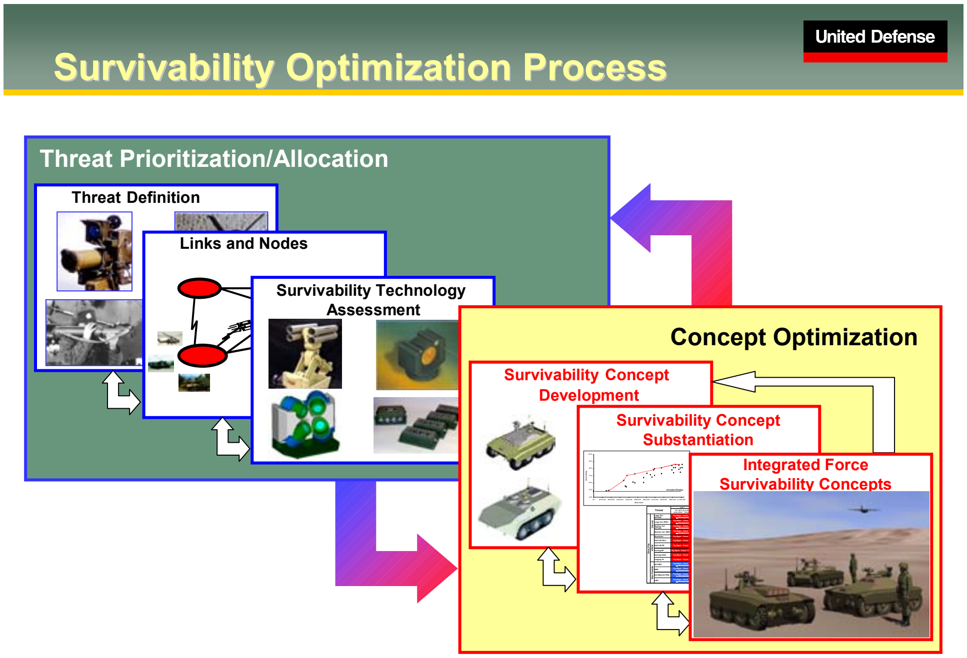
In 1997 the U.S. Army Tank-automotive and Armaments Command (TACOM) Research, Development and Engineering Center (TARDEC) awarded United Defense L.P. (UDLP) a contract to determine the most cost-effective suite of survivability technologies to protect ground combat vehicles. After contract award, the Army made a down select between a M1 Abrams and a Bradley Fighting Vehicle. The Bradley Fighting Vehicle was selected by a general officer steering committee for integration of the advanced survivability suite. The Bradley Fighting Vehicle, with the advanced survivability suite, was evaluated in a range of combat scenarios in the 2005 and 2015 time frames. The field of survivability technologies was virtually boundless, with the caveats that: (1) the suite had to be fieldable by the 2005 time frame; (2) it had to have an average unit production cost (AUPC) of less that $1,000,000; and (3) the mobility and/or fightability of the Bradley Fighting Vehicles (BFV) should not be degraded.

2.0 CONCEPT DEVELOPMENT

The primary objective of the program was to select, develop and demonstrate an optimized survivability suite. The development of this survivability suite was threat driven, cost limited, and took into account technology synergy. TARDEC provided UDLP a list of vehicles killed by a host of threat weapons from the U.S. Army A2R2 study. This was the starting point. UDLP undertook an exhaustive search of survivability technologies from armor to advanced hit avoidance and detection avoidance technologies. There was a five-step approach to concept development: threat analysis, survivability technology analysis, concept design, concept substantiation and final concept selection; the latter three were worked in iterative fashion. In brief, in threat analysis UDLP explored how threats worked, and their vulnerabilities, in survivability technology analysis we aligned the survivability technology characteristics to the threat vulnerabilities and created several concepts with those technologies integrated. In threat substantiation we took a parallel path with a series of analyses that went from a low resolution one-on-one TOSOM model with hundreds of survivability technology combinations against a mix of threats, to the low resolution many-on-many Groundwars model with a much smaller set of technologies that had emerged from the TOSOM modelling; the last stage was the high resolution many-on-many CASTFOREM model, from which three solutions emerged at different price points. These three solutions all incorporated an armor solution to defeat a more lethal medium caliber cannon threat and indirect fragmenting artillery, and laser and missile warning sensors and their processor and the Commander's Decision Aid; this common suite of technologies also included multispectral smoke. The AUPC for these common components was $483K. It was not very capable, but served as a building block for the three others. The lowest cost survivability suite added a multispectral Directable Infrared Countermeasure (DIRCM) and Laser Target Decoy Device (LATADS), both "soft kill" survivability technologies, to the common suite with an AUPC of $601K. This was referred to as the Electronic Warfare, or EW, suite. The next most capable, and next most expensive suite also built on the common suite and added an active protection (AP) system "hard kill" technology with a tracking radar, a launcher and interceptors, at a total suite AUPC of $772K. The most capable suite was a combination of the EW and AP suites, and was referred to as the "Master Suite", at an AUPC of $890K. The "Master Suite" is also referred to as the Integrated Survivability Suite (ISS). The final selection of a suite to build and test was based on the fact that Program Managers for Abrams, Bradley, Crusader or Future Scout Cavalry System would make their own selections, so by integrating and testing the master suite these PMs would have a basis for choice of hit avoidance technologies based on the best that could be offered, and they could choose EW, AP or both, depending on need and financial resources.



Survivability Optimization Process



Survivability Optimization Process

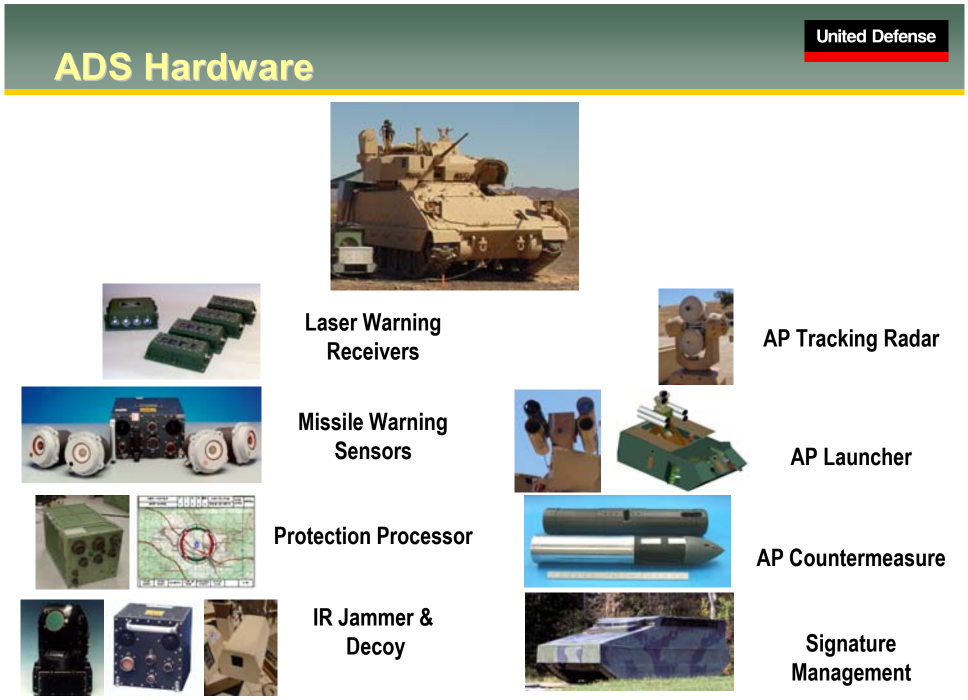
3.0 DESIGN AND INTEGRATION

3.1 Vehicle Modifications

A Bradley M2A3 EMD vehicle was used for integration and testing on the Active Defense System (ADS) Program. After the Concept Review in November 1998 UDLP, BAE SYSTEMS (BAE) and Northrop-Grumman Space Technology (NGST) (formerly TRW) began a period of hardware design and component fabrication. Integration began with vehicle modifications that were completed in June 2000. Hardware integration to ready the vehicle for EW and AP equipment took place from July 2000 through January 01.

3.1.1 Hardware Design and Integration

Hardware integration took place from July 2000 thru January 2001. This effort included the installation of numerous fabricated piece parts. Major fabricated parts included the mission module, spaced armor plates, radar/DRO support structure, sensor housings and attachment brackets for the electronics boxes. Hardware integration also included the installation and check out of several power management electronics boxes (battery box, AP power box, EW power box, motor control box, system safe/arm box, and vehicle power management.



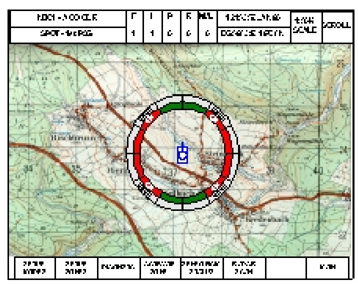
ADS Hardware

3.1.2 Software Design and Integration

The BAE Commander's Decision Aid (CDA) is the ISS tool that collects threat sensor data from various sensors, performs threat sensor data fusion, and allocates the appropriate countermeasures and backup countermeasures for the threats. The CDA interfaces to all ISS sensors and countermeasures, including the AP subsystem. The NGST AP system includes software to receive a cue from the CDA, and to manage all aspects of the tracking radar and the launcher. The BFV turret processor unit (TPU) implements the fire control, C2, soldier-machine interface (SMI), subsystem management and diagnostics for the BFV. The TPU software was modified to provide an ISS SMI for the crew, and to interface with the CDA.
A number of essential vehicle services were provided to the CDA over the TPU-CDA interface. The TPU provided INS (inertial navigation system) data to the CDA including GPS time and position, VMS (vehicle motion sensor) speed, and INU (inertial navigation unit) attitudes and attitude rates. The CDA, in turn, relayed some of these data to the AP system. These data are critical for tracking and targeting threat launch positions while the vehicle is moving. The TPU provided hatch status, so that countermeasures wouldn't be fired over open hatches. The TPU also provided BFV weapon firing status, so that the CDA would ignore self-vehicle threat detections from the ISS sensors.

Soldier Machine Interface (SMI) software, linking the ADS to the vehicle architecture, and the Commander's Decision Aid (CDA), were under development concurrently with hardware development. The CDA collects threat sensor data, performs sensor data fusion, and allocates the appropriate countermeasure and backup countermeasures. The SMI provides the Commander the capability to enable or disable various combinations of sensors and countermeasures, put the system in full automatic or semi-automatic, and set "Exclusion Zones" to protect dismounted troops. The exclusion zones are user-defined regions where the AP interceptors or jammers will not fire until the Commander disestablishes the exclusion zones. A set of ISS command, control, health, and status screens were added to the BFV TPU SMI. These screens provided a means to set countermeasure modes (active, semi-active, and disabled), and to set sensor and countermeasure exclusion zones. There were screens to display incoming threats on a compass rose around the self-vehicle icon, including threat classifications and azimuths and allocated countermeasures. Audio threat alerts (e.g., "RPG—Three O'clock!") were provided in the crew compartments of the BFV. There were screens to display previously seen threats, and there was a capability to slew the BFV Commander's Independent Viewer (CIV) to threat launch locations. There were screens to display the health and status of ISS sensors and countermeasures and various test parameters like vehicle speed and direction.

The CDA software with its AP and TPU interfaces, the AP software with its CDA interfaces, and the TPU software, screens, and CDA interfaces were developed from late 1999 through early 2001, and were integrated on the BFV in Santa Clara in mid-2001. Both the UDLP TPU and the BAE CDA software were developed with SEI (Software Engineering Institute) CMM (Capability Maturity Model) Level 3 disciplines and procedures, and the TPU software was formally qualified and tested before government witnesses.



Survivability Processor and Soldier-Machine Interface

3.2 Electronic Warfare Subsystem Integration

3.2.1 EW Integration to Support Static Testing

Preliminary EW subsystem integration took place at BAE's facility in Nashua, New Hampshire in the months preceding hardware delivery to UDLP's facility in Santa Clara in mid-January 2001 thru early-February 2001.

EW integration into the vehicle took place from early-February 2001 to early-March 01 at the United Defense SIL in Santa Clara, California. EW integration included the power distribution unit (PDU), the 60 Hz inverter, the 400 Hz inverter, the commander's decision aid (CDA) the LATADS laser head, power supply and processor, the 2-color IR sensor (1) and processor, the CMWS sensors (4) and processor, the DIRCM jam head assembly (JHA) and jam head control unit (JHCU) and numerous cables.

During testing, a thermal electric (TE) cooler was added to the 2-color IR sensor. Fans and ducting to cool the TE cooler were also integrated behind the left front spaced armor plate at this time.

3.2.2 EW Integration to Support On The Move Testing

EW hardware for AOTM integration arrived on site in YPG in early November 2002. The first 2 weeks were dedicated to integration, followed by testing and integration working in parallel. The CMWS sensors (4) and processor, the directable IR countermeasure (DIRCM) jam head assembly (JHA) & jam head control unit (JHCU), the CDA and numerous cables were installed. The CMWS test instrument processor (CTIPs) recorders (3), power supplies (2) and processor were also integrated at this time. Integration began with the mechanical installation of equipment, followed by power checks, stimulation of sensors, and stimulation of sensors with corresponding operation (pointing) of the DIRCM.

3.3 Active Protection Subsystem Integration

3.3.1 AP Integration to Support Static Testing

AP subsystem integration took place at Northrop-Grumman in the months preceding hardware delivery to UDLP in March 2001. Integration included the AP launcher assembly, the radar assembly, the test set box, the dielectric resonance oscillator (DRO) and numerous cables. During integration a cooling fan was added for the DRO and a universal power supply (UPS) was added to protect against uncontrolled power shutdowns.

In April 2001 the EW/AP interfaces were checked, and in May 2001 the Vehicle Interface System (VIS) was checked. In June 2001 vehicle integration was completed and passed on for test.

3.3.2 AP Integration to Support On The Move Testing

The launcher assembly, radar assembly, DRO, Test Set and numerous cables were re-installed. Brackets were designed to securely mount the Squad Leader's Display, to mount the UPS, and to mount a high-speed camera on the turret exterior.

3.4 Vehicle Remote Integration

The Remote Vehicle Operation system was installed in September-October 2002. It consisted of a vehicle processor, power supply, several actuators and mobile station controller. Actuators were used to control steering, braking, gear selection and the throttle. A solenoid was used for fuel shut off. The system operated by differential GPS. One GPS antenna was installed on the vehicle, and another was installed adjacent to the mobile control station. The GPS near the mobile control station was located on a known survey point, thus allowing very accurate measurements of the vehicle. To operate the vehicle remotely, the vehicle was first driven manually down the test track, while taking GPS waypoints along the way. Remote operation was subsequently achieved by comparing the position and time at each waypoint.

4.0 TEST

4.1 Test Concept

Testing followed a step-wise approach beginning with component testing and culminating in system level end to end live threat defeat tests. Where feasible, various component level tests and subsystem level tests were conducted in parallel.
System level testing also followed a step-wise approach, often referred to as the "crawl, walk, run" approach, beginning with system checkout in a systems integration laboratory and culminating in end to end live threat defeat tests.
The development of the test program was threat driven. Selection of the primary test facility, selection of the specific test site, and test site layout and construction were driven by the land and airspace requirements of the various munitions used in the test program. Development of the test plan and test procedures were driven by the specific threat defeat requirements outlined in the ADS threat list.

4.2 Subsystem Testing

4.2.1 EW Subsystem Testing

EW component testing was conducted December 1999 through December 2000.

EW subsystem level testing was conducted December 2000 through January 2001.

EW signature collection tests were conducted in April 2001.

4.2.2 AP Subsystem Testing

AP component testing was conducted October 1999 through May 2000.

AP subsystem testing was conducted in three phases. The first phase was conducted June through December 2000 at Northrop Grumman. The second phase was conducted October through December 2000. The third phase was conducted in March 2001.

4.3 System Testing

4.3.1 Static Testing

Static testing was conducted in four phases using the "crawl, walk, run" methodology outlined in the test concept.

Phase I was the "crawl" stage. Testing was conducted during June and July 2001.

Phase II was the "walk" stage. Testing was conducted during July and August 2001.

Phase III was the "run" stage. Testing was conducted during September 2001 to June 2002. The purpose of this test phase was to demonstrate full end-to-end system capability against full caliber live munitions from a stationary platform.

Dual Defeat of Threat by AP and EW Simultaneously in Static Test

4.3.2 On the Move Testing

Accelerated on the Move Testing (AOTM) was conducted during October 2002 to May 2003. The purpose of this test phase was to demonstrate full end-to-end system capability against full caliber live munitions from a moving platform.

Active Protection Hard Kill Defeat of Threat While Moving at 20 mph

Electronic Warfare Soft Kill Defeat of Threat While Moving at 20 mph

Acronym List

AP-active protection (hard kill system)
DRO-dynamic resonance oscillator
EMD-engineering, manufacturing and development program
CDA-commander's decision aid
ADS-active defense systems
AOTM-accelerated on-the-move program
MOTM-matured on-the-move program
YPG-Yuma Proving Grounds
SIL-system integration laboratory
EW-electronic warfare
GPS-global positioning system
VIS-vehicle interface system
LATADS-laser target decoy system
CMWS-common missile warning system
DIRCM-directable infrared countermeasure
JHA-jam head assembly
JHCU-jam head control unit
TE-thermal electric cooler
TPU-turret processor unit
SMI-soldier machine interface
INS-inertial navigation system
ISS-integrated survivability suite
UPS-universal power supply