National Bomb Squad Commanders Advisory Board

Presentation to the

2011 Ground Robotics Capabilities Conference

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Introduction

- Bomb Squad Robot Definitions and Requirements
- Robot Related Projects
  - Test Bed at Michigan State Police
  - VBIED Robot Standards Working Group at NIST
  - R&D Efforts

Deployed Robots Among U.S. Bomb Squads

Platform	Quantity
Andros F-6	**36**
Andros F-6A	**285**
Andros HD-1	**14**
Andros Mini-2	**55**
Andros MK V	**16**
Andros MK V-A1	**23**
Andros MK VI-A	**7**
Andros Wolverine	**15**
Icor Caliber	**5**
MURV-100	**5**
Other	**53**
Pedsco RMI-9	**24**
Talon	**30**
Vanguard MK-2	**46**

Robot Definitions in the National Guidelines for Bomb Technicians

Origin of Bomb Squad Robot Definitions

- NBSCAB responded to DHS FEMA requirements to define bomb squads (and all other responder groups) into a Type I, Type II, Type III,… format so that incident commanders could distinguish among various capability levels of resources being requested to support crisis events.
- NBSCAB steered this typing into a direction that would recognize bomb squads that were equipped to handle VBIEDs
- Based on this VBIED capability requirement, a need emerged to define a “VBIED capable robot.”
- Now the challenge is to provide some precise technical specifications to those definitions.

Robot Definitions in the National Guidelines for Bomb Technicians

***Unmanned Ground Vehicle (UGV):** A powered, mobile, ground conveyance that does not have a human aboard; can be operated in one or more modes of control (i.e., autonomous, semi-autonomous, teleoperation, remote control); can be expendable or recoverable; and can have lethal or non-lethal mission modules.

Teleoperation: A mode of continuous control wherein the human operator uses video feedback and/or other cues to directly control the actions of the UGV.

*As defined by the Joint Robotics Program Master Plan – 2004, published by OUSD (AT&L) Defense Systems/Land Mine Warfare and Munitions, 3090 Pentagon, Washington, D.C. 20301-3090.

Robot Definitions in the National Guidelines for Bomb Technicians

General Service Bomb Response Robot: A UGV capable of being operated in a teleoperation mode of control plus having a minimum:

- 300 feet range of operating distance from the human operator
- 2-hour mission duration without the need to replace/recharge the primary power source
- 6-inch obstacle clearance
- Outfitted with bomb disablement tools which includes, but not limited to:
  - Standard disrupter, with onboard aiming and firing capability
  - Mineral Water Bottle (MWB) or similar general type disruption tool with onboard firing capability
  - Manipulator Hand

Robot Definitions in the National Guidelines for Bomb Technicians

VBIED Capable Bomb Response Robot: A Bomb Response Robot that meets all of the requirements for a General Service Bomb Response Robot, plus capable of the following:

•Outfitted with a tool designed for breaking a side window in a passenger vehicle;

•Deploying, aiming and firing a PAN or similar gun type disrupter through the open window of a large sedan or Sport Utility Vehicle (SUV) and effectively engaging a package located at any position in the vehicle visible from the open window;

•Deploying and firing a MWB or similar general type disrupter through the open window of a large sedan or SUV and effectively engaging a suspicious package located at any position in the vehicle visible from the open window;

•Deploying and firing an overpressure disruption charge through the open window of a large sedan or SUV;

Robot Definitions in the National Guidelines for Bomb Technicians

VBIED Capable Bomb Response Robot: (continued)

•Operating it's manipulator through the open window of a large sedan or SUV at any position in the vehicle visible from the open window;

•Carrying, delivering, and firing a Bootbanger or similar ejection tool to a position underneath the trunk of a large sedan or SUV without the aid of a separate carrier;

•Deploying an ejection-type tool mounted on a separate cart alongside a target vehicle, such as the Modular Large Vehicle Disrupter (MLVD) or similar type disrupters**;**

•Being off-loaded from the bomb squad response vehicle, loaded with any one of the above weapon systems, and moved to a target 300 feet downrange within 20 minutes.

Options for VBIED Defeat Techniques

- Remote surgical disruption of a key circuit component
- Remote general disruption of the circuit
- Remote disassembly
- Remote attack focused on the main explosive charge (Expulsion tools)
- Manual attack

Development of these VBIED defeat options in 2009 placed an even greater burden on robot requirements.

Robot Definitions in the National Guidelines for Bomb Technicians

VBIED Capable Bomb Response Robot:

- **Disassembly Capable Bomb Response Robot**: (proposed) A Bomb Response Robot that meets all of the requirements for a General Service Bomb Response Robot, plus capable of the following:
  - Outfitted with a multipurpose interchangeable Spreader & Cutter Tool that uses non-energetic disassembly methods for responding to various threats and operations including VBIED, PBIED, package bombs, pipe bombs, hostage rescue, etc.
    - For VBIED response: Capability to gain access into vehicles, such as opening truck roll-up and trailer doors, opening vehicle side and rear doors, cutting vehicle posts and hinges, opening trunks and hoods, breaking window glass, etc.
    - *(There are additional sections for PBIED and other purposes, but not shown here.)*

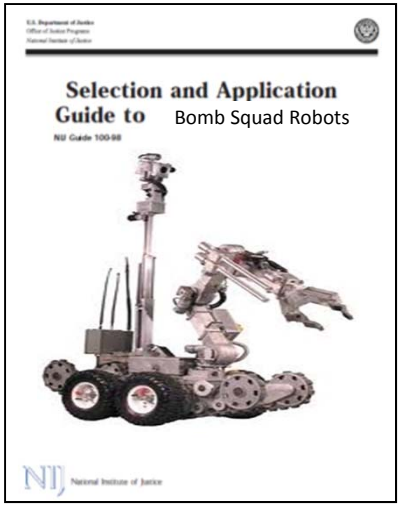
Response Robot Requirements Workshop for Vehicle Borne Improvised Explosive Device Applications

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

- An initial workshop was conducted January 26-28, 2011 at the NIST facility in Gaithersburg.
- Standard test methods are being developed to evaluate the performance of bomb squad VBIED capable robots.
- Bomb squads will be able to refine their requirements.
- Robot manufacturers will gain access to statistically significant performance data.

Development of Robot Standards

- NBSCAB will take the results from the NIST working group and work with NIJ to develop a Selection and Applications Guide, as the first step toward building bomb squad robot standards, with emphasis on VBIED capability.



Critical Incident Response Technology Seminars (CIRTS)

- **Top Robot Requirements Identified in 2010**
- Ability to operate the RCV in a wireless mode w/o line of sight between RCV & OCU
- Ability of robot units to operate during missions in close proximity w/o interfering with each other
- Ability to deploy large vehicle access and disruption tools from the RCV. (Bootbanger, MLVD, etc)
- Ability to x-ray a suspect device through the robot and view image on the OCU
- Desire a fiberscope with a wide-angle view, and 10x zoom which is integrated for use by RCV.
- Ability to view the position of the platform, manipulator arm and end effector on the OCU monitor
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- Ability to strengthen the robot arm when using heavy water charges
- Ability to have the pose and position of the Platform, manipulator arm and end effector displayed
- Desire a fiberscope with a wide-angle view, and 10x zoom which is integrated for use by RCV.
- Ability to strengthen the robot arm when using heavy water charges
- Desire maximum degrees of freedom and motion on all joints of the robot arm
- Ability to view from the end effector camera with the end effector in any position
- Ability to have remote plug and play modules
- Desire better dexterity articulation when using the gripper inside of a vehicle
- Ability to have multiple end effectors with different capabilities
- Ability to sense depth/distance from the OCU monitor.
- Desire better visualization under all light conditions from robot systems improved cameras
- Ability to deploy large vehicle access and disruption tools from the RCV. (Boot banger, MLVD, etc).

DHS S&T Test Bed at Michigan

Power Hawk
Non-Energetic Remote Access Tool "NERAT"

Power Hawk NERAT testing at Michigan State Police determined that it is an effective disassembly tool, capable of gaining access to cargo areas.

DHS S&T Test Bed at Michigan Robot Related Observations

- Mobility
  - Small Vehicles
  - Large Vehicles
- Strength
- Cameras
- Communications
- Manipulators and Tools
- Weapons
- Sensor Attachments
- Power
- Human Factors
- Reliability
- Other considerations

DHS S&T Test Bed at Michigan Robot Related Observations

<u>Sedans</u>

- Limitations within open door areas
- Large arms are limited within vehicles especially trunks and rear seats
- Challenges keeping trunks and doors open

<u>Trucks</u>

- Height challenges
- Cab surveillance
- Access to cargo area (locks and j-hooks)
- Truck cargo beds difficult to access
- Distant disablement shots within cargo areas
- Reading from a distance
- Getting robots into trucks

DHS S&T Test Bed at Michigan Robot Related Observations

Strength

- Manipulators such as Power Hawk (30+ lbs)
- Towing tools such as AXISS (350 lbs +)
- Opening and bending doors/trunks
- Lifting full containers (e.g. fuel containers)
- Carrying disablement charges (DEBIT, MLVD)

Weapons

- Dual disrupter mounts very useful
- Nearly always fired both disrupters on VBIED responses for access and disablement
- Weapons reduce mobility inside vehicles
- Targeting and distance measurement

DHS S&T Test Bed at Michigan Robot Related Observations

Mounting Sensors

- No standard placement methods or locations
- Optimization of sensor location and field of view
- Need for sampling tools
- Ability to transmit data

Camera Issues

- Obscurants: Dust, water drops, window glare, tinting
- Off-axis placement improves view but limits access
- Resolution for reading at a distance
- Low-light capabilities
- Visibility of targeting lasers
- Over watch cameras help to clearly view truck interiors
- Need for multiple operators to see each others' view

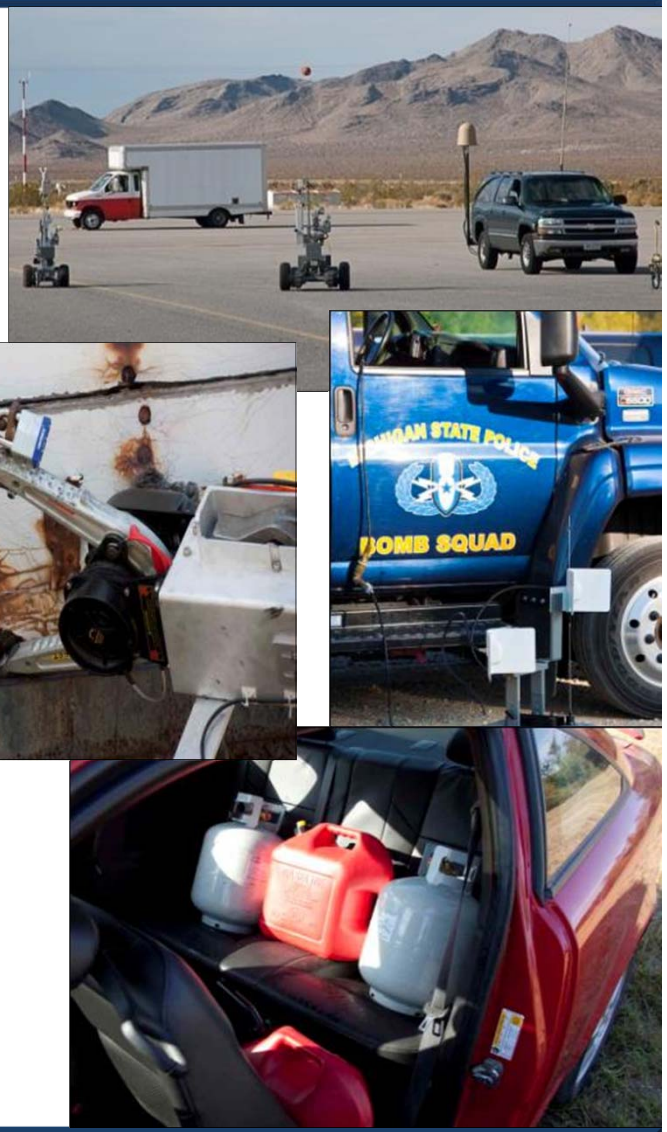
DHS S&T Test Bed at Michigan Robot Related Observations

Communications

- Range requirements in VBIED response
  - Long distances from ICP to target
  - Urban canyons
- Fiber Optic considerations
  - Length
  - Multiple robots and overlap of fibers
- Two way robot comms for downrange techs
- Difficulty getting frequency allocations
- Backbone for additional systems

Manipulators and Tools

- Variable end effectors
- Window breakers, etc
- Grabbing items within vehicles
- Limited mobility
- Opening locked and unlocked doors



DHS S&T Test Bed at Michigan Robot Related Observations

Power

- Response will likely be several hours long (potentially 5+)
- Response will involve long travel times from ICP to target (potentially 1000+ yards)
- Alternate power sources desirable
- Hybrids, Fuel Cells, Li-Ion batteries

Human Factors

- Dual robot operations
- Requirements for multiple robot training
- Human-Robot Interaction
- Navigation
- Perception & Intelligence

DHS S&T Test Bed at Michigan Robot Related Observations

<u>Reliability</u>

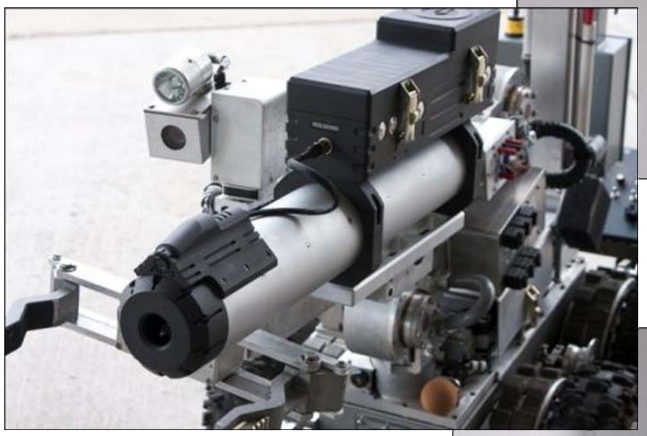
- Frequent breakdown even on well maintained robots
- Baseline Assessment
- Power supply
- Communications
- Thrown track
- Power Hawk
- Multiple broken arm gears

<u>Other Considerations</u>

- Improvised Situational Analysis
- Need a means of determining robot orientation to avoid overturning
- Audio to listen to sensors
- Potential for operations in spilled fuel

DHS S&T Project: TVEDS

Tactical Visual and Explosive Detection System

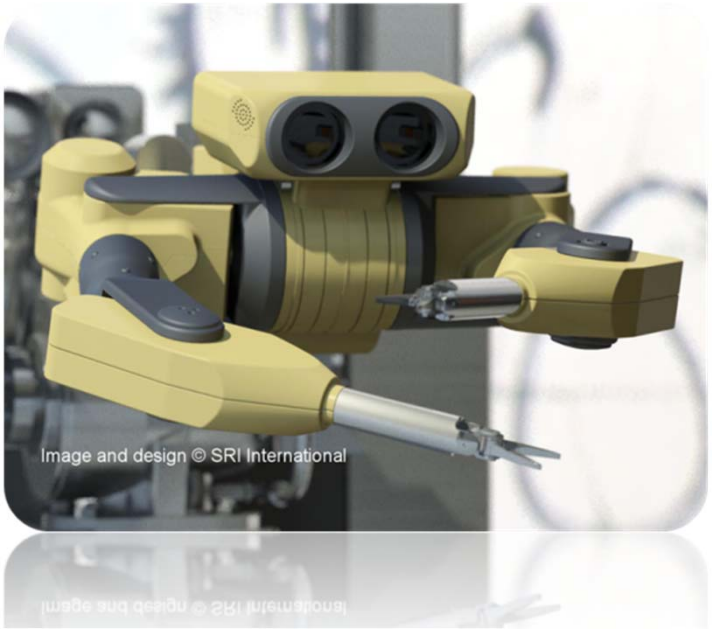


Ability to drill into a vehicle, insert video camera
Can be attached to the F6A and Wolverine Robot arm
Self-contained system with its own power and communications
Minimal signature or disturbance to the VBIED
Integrate with current counter IED tools

DHS S&T Project: Taurus

Intuitive Bomb Squad Dexterous Telemanipulator

- TAURUS is a revolutionary, low-cost, robust dexterous telemanipulation system developed with funding from DHS S&T for municipal bomb squad VBIED countermeasures.
- The bi-manual OCU with stereoscopic display will be key to user acceptance and high-performance telemanipulation. This system is based on technology used for robotic surgeries.

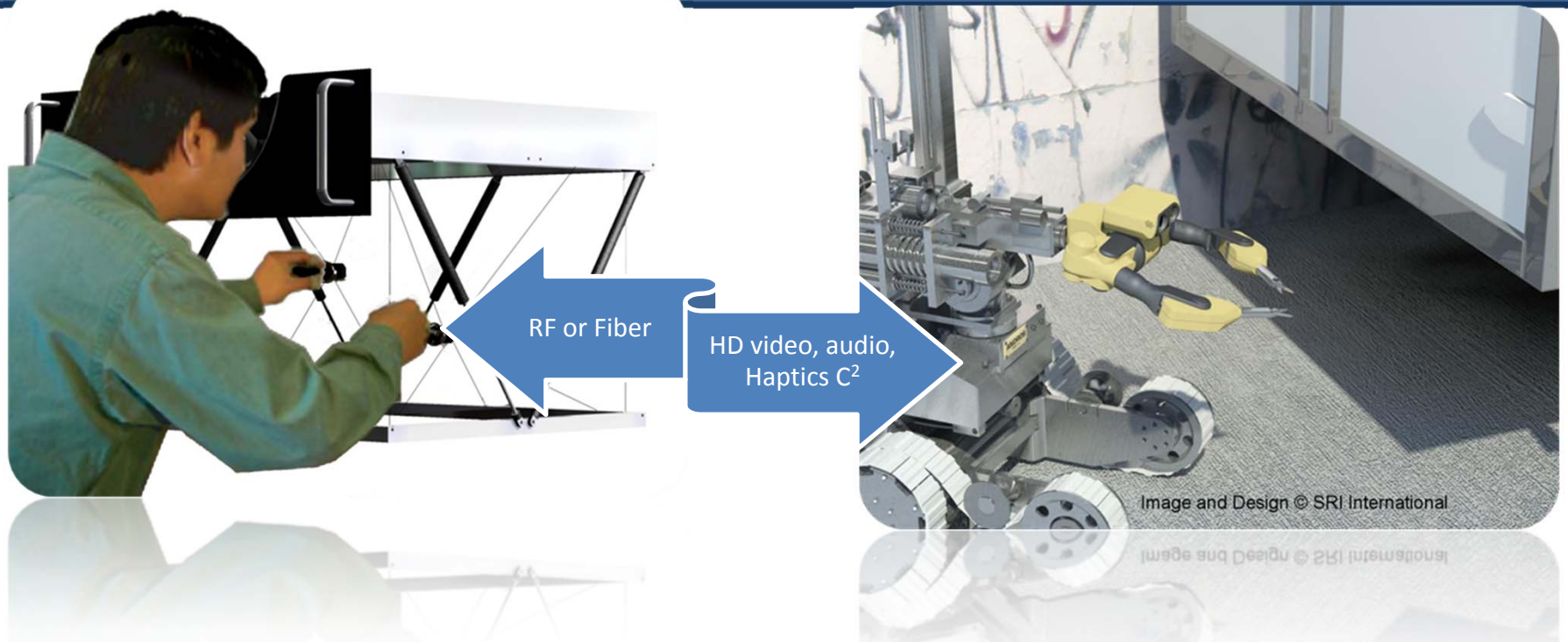


<u>Manipulator Features</u>

- 2 independently controlled 7 DOF robot arms
- Multi-functional cutter-graspers
- Stereoscopic HD camera w remote tilt-zoom-focus
- 5 pound payload. 42 x 33 x 33 in. workspace
- Modular and rugged design
- Compact 15 lb slave system weight
- Vehicle entry porthole size of 14”x5.2”
- Mounts to Andros F6-A or similar mobile EOD platform used by domestic bomb-squads

DHS S&T Project: Taurus

Intuitive Bomb Squad Dexterous Telemanipulator



Operator Control Unit Features

- Wireless digital RF link or fiber optic tether
- Portable 3D display with haptic feedback
- 3D haptic force, vibration and grip effort feedback through the arm control devices.
- Intuitive HRI adapted from SRI patented surgical robot enables effective manipulation performance.

Overall System Features

- Independent power, comms and OCU
- System production cost target of $30k

NBSCAB work with US Air Force on RONS Transfer to Law Enforcement

- US Air Force initiative to transfer RONS to civilian bomb squads, ATF, and FBI
  - First 7 robots have been successfully transferred
  - Process for turn-in and transfer now ready to move forward with turn-in of operational RONS
- Robots being transferred under 1997 National Defense Authorization Act, section 1033
  - Focus on getting counter IED and counter drug equipment to civilian law enforcement
- Benefits: reduces off-base responses for CONUS JSEOD; provides C-IED assets to our civilian bomb squads, leads to faster responses, better equipped bomb squads, more capable law enforcement agencies, ultimately leading to safer communities

Questions??

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