

National Unmanned Systems Experimentation  
Environment (NUSE2) Field Experiment – F.E. Warren AFB



Good Afternoon,

I'm Kevin Hodges, Program Manager, for AFRL's Remote, Detection, Challenge and Response (REDCAR) project and today I'm going to discuss with you the National Unmanned Systems Experimentation Environment (NUSE2) sponsored experiment conduct and F.E. Warren AFB.

**REPORT DOCUMENTATION PAGE**

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<b>14. ABSTRACT</b> The Air Force Research Laboratory, Robotics Research and Development Group have developed and demonstrated a proof-of-concept robotic perimeter security system for the USAF Force Protection Battlelab. The REDCAR project (Remote, Detection, Challenge, and Response) evaluated the utility of mobile robotic systems for installation security missions during a series of operational demonstrations in November of 2005 at F.E. Warren AFB. For the REDCAR project, AFRL has developed a high-speed ground robotic system (SCOUT) and integrated existing robotic platforms (MDARS-E and Matilda) with the USAF Integrated Base Defense Security System (IBDSS).					
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## **REDCAR**

### **Project Overview**



#### **Force Protection Battlelab Initiative**

- **Demonstrate the benefits of unmanned systems for the security force operations with the primary mission of perimeter defense of Air Force installations and forward deployed units**
- **Network of robotic platforms integrated with existing security force Integrated Base Defense Security System (IBDSS) sensors**
- **The AFRL Force Protection Branch, Robotics Research and Development Group is the technical developer and program manager for the REDCAR initiative**
- **Operational requirements for REDCAR are in the Integrated Base Defense 2020 Concept of Employment (IBD2020 CONEMP)**

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REDCAR began as a Force Protection Battlelab Initiative to determine the feasibility of unmanned systems conducting primary defense missions Air Force installations, sites and forward deployed units.

REDCAR is not a platform developed by any single lab or company. It is a systems of JAUS compliant platforms on a common network controlled through a single operator control unit, (used) with an Integrated Base Defense Security System

The FPBL enlisted the services and capabilities of the AFRL Force Protection Branch, Robotics Research Group as the tech developer and program manager for this initiative.



## Force Protection Branch



Air Force Research Laboratory  
Materials and Manufacturing Tech Directorate  
Airbase Technologies Division

Operations  
Support Branch  
(MLQO)

Airbase Sciences  
Branch  
(MLQL)



Deployed Base  
Systems Branch  
(MLQD)

Force Protection  
Branch  
(MLQF)

### Robotics Research Group Mission

- The Air Force's *Robotics Research Group* conducts research and development of advanced robotic technologies and systems to protect, support, and augment the warfighter in the accomplishment of dirty, dull, dangerous, and impossible missions.

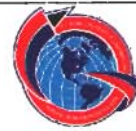
- **Robotics Research Group**
- Security Engineering and Explosives Research Group
- Range Operations and Support Group

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When most people hear AFRL they often ask Wright-Patt? AFRL HQ is located at Wright- Patterson AFB, OH but our detachment the Airbase Technologies Division, under the Materials and Manufacturing Directorate is located at Tyndall AFB near Panama City, Florida.



## **REDCAR** **Participants**



### **USAF**

- **Force Protection Battlelab - FPBL**
- **Air Force Research Laboratory**  
**AFRL/MLQF Robotics Research Group**
- **Electronic Systems Center – ESC/FD**

### **USA**



- **Program Manager - Force Protection Systems - PM-FPS**





### **USN**




- **Space & Naval Warfare Systems Center**  
**- SPAWAR Unmanned Systems Branch**

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Naturally we did not complete this effort on our own. In addition to our organization and the FPBL we had the assistance for the Electronic System Center from Hanscom AFB, PM-FPS and SPAWAR were instrumental in providing support from the MDARS program.

 **REDCAR**   
**Eglin Proof of Concept Demonstration**  
**Results**

- **High Speed Assisted Teleoperation to 40 mph** 
- **Tiered response with lethal and less than lethal weapons** 
- **J AUS Network of unmanned mobile systems** 
- **Integrated with USAF Tactical Area Security System (TASS)** 


 **Accomplished**     **Partial Success**     **Unsuccessful**

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These were the four main objectives of the proof of concept demonstration and as the slide depicts, we were successful in accomplishing each objective. Of particular note was the development of high speed assisted teleoperation at high speeds to aide system operators in controlling vehicle movements.




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# REDCAR

## System of Systems



**Network of platforms for tiered response**

	<p><b>Surveillance platform</b></p> <ul style="list-style-type: none"> <li>➤ area surveillance duties--limited intruder challenge</li> </ul>	
		<p><b>Engagement Platform</b></p> <ul style="list-style-type: none"> <li>➤ perform the challenge, response, and delay components (lethal response capability)</li> </ul>
<p><b>Small-scale Platform</b></p> <ul style="list-style-type: none"> <li>➤ reconnaissance in limited access areas</li> </ul>	<p><b>C2ISR System</b></p> <ul style="list-style-type: none"> <li>➤ single OCU for all systems</li> </ul>	

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Earlier I said REDCAR was not a platform but system of JAUS compliant platforms, here is a great example of that concept.

The MDARS platform served as the surveillance platform for the experiment by performing random patrols and static sentry missions

The small scale platform, either a JAUS compliant PACKBOT or Matilda, was not used in the FE Warren experiment because the experiment area did not afford the opportunity to exploit the small platform capabilities. However, the mission of these platforms is to conduct surveillance and recon of areas inaccessible to the larger platforms.

The engagement platform was the AFRL developed Scout vehicle, a military variant of the Polaris Sportsman ATV with surveillance, non-lethal and lethal payloads.

The C2ISR System provided a single operator control unit for all systems





# REDCAR

## Surveillance Platform

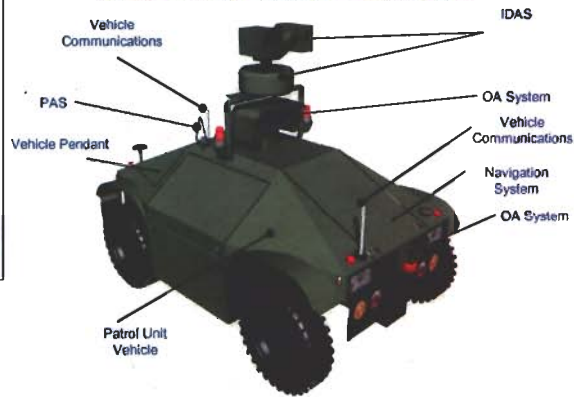


### Surveillance platform

- > Area surveillance duties with limited intruder challenge and response capabilities
- > JAUS compatible MDARS
- > SDD MDARS-E system with Obstacle detection system, Intruder detection system, RF Tag reading system
- > Future plans to install a non-lethal response capability

### MDARS

Mobile Detection, Assessment & Response System



Built by General Dynamics Robotics Systems – GDRS  
For the US Army Program Manager – Force Protection Systems – PM-PSE

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# REDCAR Engagement Platform



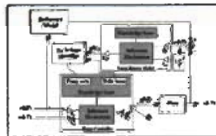
## SCOUT



- Engagement Platform**
- > Perform the challenge, response, and delay components
  - > JAUS compatible REDCAR SCOUT robot built by AFRL
  - > Traverse over rough terrain, and through heavily wooded areas
  - > Waypoint navigation up to 20mph - with obstacle avoidance.
  - > Teleoperated motion at high speed - 49 mph sprint
  - > Primary patrol mode will be on pre-surveyed routes
  - > RSTA system payload with EO, IR, Night Vision, Laser Rangefinder
  - > Lethal & non-lethal weapons systems
    - > NLW: Pepper Spray Fogger with marking dye
    - > LW: Precision targeted rifle M16A2



Obstacle Avoidance



Velocity Controller

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## F.E. Warren Experiment 9 – 16 May 05



- National Unmanned Systems Experimentation Environment (NUSE2) experiment to perform semi-autonomous physical security in relative environment with on-duty security forces
- No NUSE2 site has on-duty security forces performing physical security protection mission – F.E. Warren selected
- Meets AFRL need for robust operational experiment
  - Determine research requirements for advanced robotic behaviors
  - Determine research requirements for machine/human interface
  - Produce data for SF planners to develop CONOPS and operational requirements

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Shortly after the proof of concept demonstration we were asked to conduct a demonstration under the NUSE2 program. After evaluating our need for an experiment in a relative environment we began coordination for access to F. E. Warren AFB to conduct an operational experiment with the intended user community.

We planned for the experiment to serve as the center point to focus our R&D efforts and to provide SF planners data necessary for realistic CONOPS for unmanned systems and to serve base line for operational requirements



## F.E. Warren Experiment

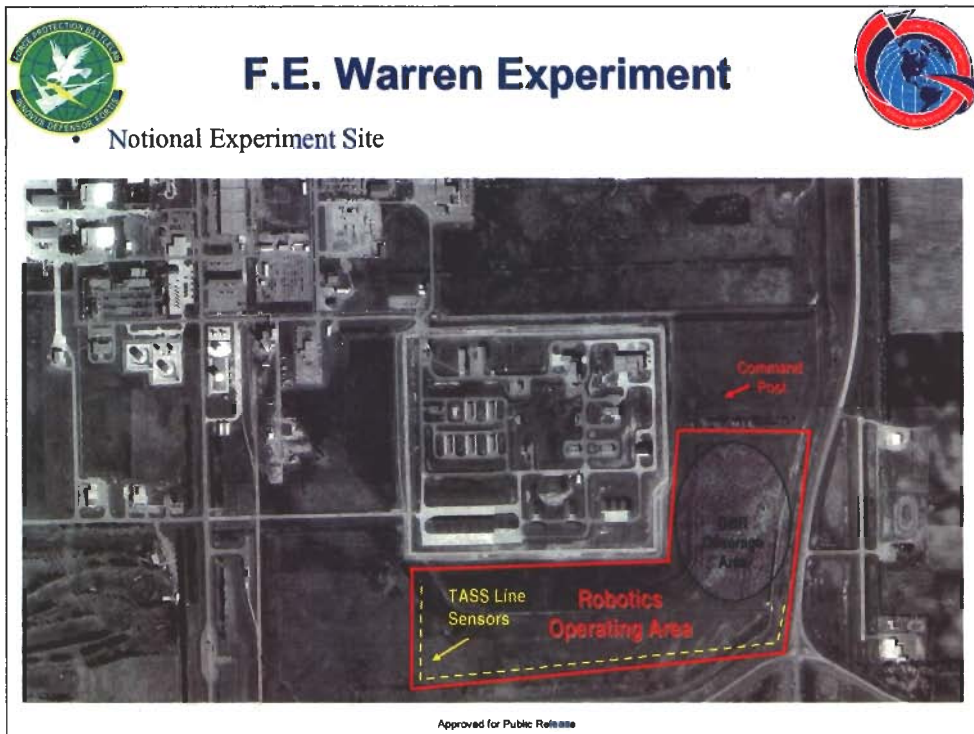


- Experiment Plan
  - Deploy AF Security Forces Tactical Automated Security Systems (TASS) with Ground Based Radar as stand-off detection system near Weapons Storage Area
  - Provide orientation training Security Forces Squadron personnel as system operators
  - Integrate platforms into existing security force structure to conduct stand-off detection and challenge missions
  - Capture data from experiment to guide research and development plans for robotic platform capabilities

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Our approach for the experiment was simple and straight forward, we needed to operate in as near a “normal” operating environment

- We placed unattended ground sensor in the area surrounding the weapons storage area to provide stand off detection
- The local security forces squadron provided operators to us during each tour of duty and after a little orientation on the system, SF personnel operated the platforms under the supervision of AFRL personnel
- We blend the robotic systems into the day-to-day security operations alongside posted security forces
- And at the end of the experiment we established a guide to lead further research and development efforts based on early user feedback and input.



Due to security concerns by the host installation, I am unable to show you the actual area we conducted the experiment, however thanks to the internet I am able to show you a notional depiction of a REDCAR experiment site .

Essentially you have and area protected by on-duty response forces and sensor systems typically along fence lines marking legal boundaries

We added stand-off detection through to use of tactical sensors and ground based radar and added stand-off response and challenge through the introduction of remotely operated systems



## F.E. Warren Experiment How Did We Do?



- Exercise Response:
  - Stand-off Detection and Assessment:
    - One exercise aggressor identified during major response force exercise using surveillance payload approximately 605 meters from platform
      - Directed Security Forces to aggressor location – no friendly forces lost
    - Ground radar detected exercise aggressor crawling toward restricted area; used surveillance infrared payload to locate aggressor and direct security forces to interdict—aggressor in custody of Security Forces 350 meters from restricted area perimeter
    - Intercepted intruder along Northwest boundary of the restricted area; challenged suspect and delayed intruder until arrival security force

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During a major force-on-force exercise we were able to use our surveillance to detect an exercise aggressor at a distance of approximately 605 meters from our platform. We then directed responded forces to the excise aggressors location.

Our ground radar detected a target approaching the area we were protecting. We dispatched the Scout platform to assess the alarm. Using our IR surveillance payload we detected an exercise aggressor crawling towards the restricted area and directed security forces to intercept. The aggressor was in SF custody 350 meters from the restricted area boundary. This represents a 350% increase in detection, assessment and response capability over current technology.

The last example of our success was demonstrated when we intercepted an exercise intruder moving along the restricted are perimeter, we were able to perform a remote challenge of the suspect and placed in a position of disadvantage until security force could arrive.



## F.E. Warren Experiment What Did We Learn?



- Research and Development Areas:
  - Advanced Robotic Behaviors
    - Navigation
    - Alarm Response
    - Diagnostics/Maintenance/Repair
  - Human/Machine Interface

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-The recurring lesson learned from our experiment was these systems require advanced autonomous capabilities in order to be effective in security force operations. The idea of an operator sitting behind an operator control unit does not excite anyone in the user community. These systems must complete a majority of their assigned duties independent of operator input in order to increase ease of operation.



## F.E. Warren Experiment What Did We Learn?



- Research and Development Areas:
  - Advanced Robotic Behaviors
    - Navigation
      - World modeling (**update/learn** changes in environment)
      - Dynamic environment operations (OA)
      - Communication loss navigation behaviors

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-In the area of advanced robotic behaviors

-Navigation

-Unmanned systems developed for day-to-day operations in dynamic environments need the capability to update or learn changes in the environment as the systems traverse the operating area and share this information is all systems on the network. The ability to record obstacle and terrain data will greatly assist operators in efficiently employing these systems and allow systems to independently determine the safest, quickest route from point A to point B. .

- Obstacle Avoidance needs to migrate toward “obstacle classification”...systems need to be able to determine the “traversability” of perceived obstacles. “Vegetation vs. boulder decision making”.

- The last area in navigation to consider is what behaviors do we want robotic systems to possess when communications are lost. This is more of a “policy” or procedure instead of a technology challenge however early decisions on policy will make the selection of technology solutions a little easier.





## F.E. Warren Experiment What Did We Learn?



- Research and Development Areas:
  - Advanced Robotic Behaviors (Continued)
    - Alarm Response
      - Situational awareness (what alarm was triggered)
      - Alarm assessment (self-path planning to assess sensors, look-at-commands and go-to-commands; what is the assessment behaviors for the platform, autonomous challenge behaviors)
      - Hostile engagement (non-lethal/lethal with assisted target acquisition and tracking/IFF)
      - Self protection
    - Diagnostics/Maintenance/Repair
      - Refuel/recharge
      - Graceful Failures (operate safely as failures occur/self-healing)
      - Redundant systems

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-In the area of Alarm response we rapidly discovered the need for autonomous alarm investigation behaviors to assist platform operators

-Integration into existing alarm systems is necessary to provide the situational awareness to determine what sensors of the security system have been triggered and what assessment priority as been assigned.

-Alarm response behaviors need to include self-path planning for the systems to determine the fastest response route to intercept an intruder prior to the intruder reaching the protected area. Platforms must also be able to conduct autonomous challenge of intruders and possess the ability to keep itself between the resource being protected and the intruder to provide maximum delay to the area perimeter. (LSU – Automated Target Engagement Methods)

-Systems intended for defensive and offensive operations with lethal capability need Assisted Target Acquisition and affordable engagement on the move capability of moving targets. (P2SUMS) In addition, in fog of war especially in limited visibility, Identify, Friend or Foe (IFF) technology will be an absolute must.

-And lastly platforms providing physical security response capability will need to have autonomous self-preservation behaviors to prevent unauthorized user from gaining access to the vehicle.



## F.E. Warren Experiment What Did We Learn?



- Research and Development Areas (cont):
  - Human/Machine Interface
    - Cognitive task analysis and human effects studies to determine ergonomics, information/visual presentation, audio interface and operator saturation



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In the area of Human/Machine interface once again the level of autonomy built into systems we have a large role in how information is presented. For the average user information needs to be minimized to the amount necessary for vehicle and payload operation.

Visual information must be presented from the user intuition perspective vs. the developer perspective.

Example: Users preferred the view on the left vs. the view on the right while driving the vehicle.

And lastly how information is too much and when does operator saturation occur. Simply we are often asked how many robotic systems can one operator control? Regardless of network capability one operator can control only one robot in teleop mode at a time.



## F.E. Warren Experiment What Did We Learn?



- Research and Development Areas (cont):
  - Platform Operational Requirements
    - **Highly agile** – skid steer/four-wheel steering, **low CG**, **high speed 40+**
    - **High performance off-road suspension**
    - **Commercially light weight armor** – NIJ Standard Level IV
    - **Redundancy for communications system-self selecting for best performance**
    - Although custom **vehicle is probable**, **maximize commercially available parts** where possible
    - **Mission duration of 12-hours minimum**; **silent operation** for payloads **6-hour minimum-self-status** for recharging **battery powered** payloads
    - **One vehicle type most likely** will not meet **all needs** depending upon **topography, weather and operational constraints** of the installation

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# F.E. Warren Experiment



Questions?

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