Semiconductor Ultraviolet Optical Sources

SUVOS

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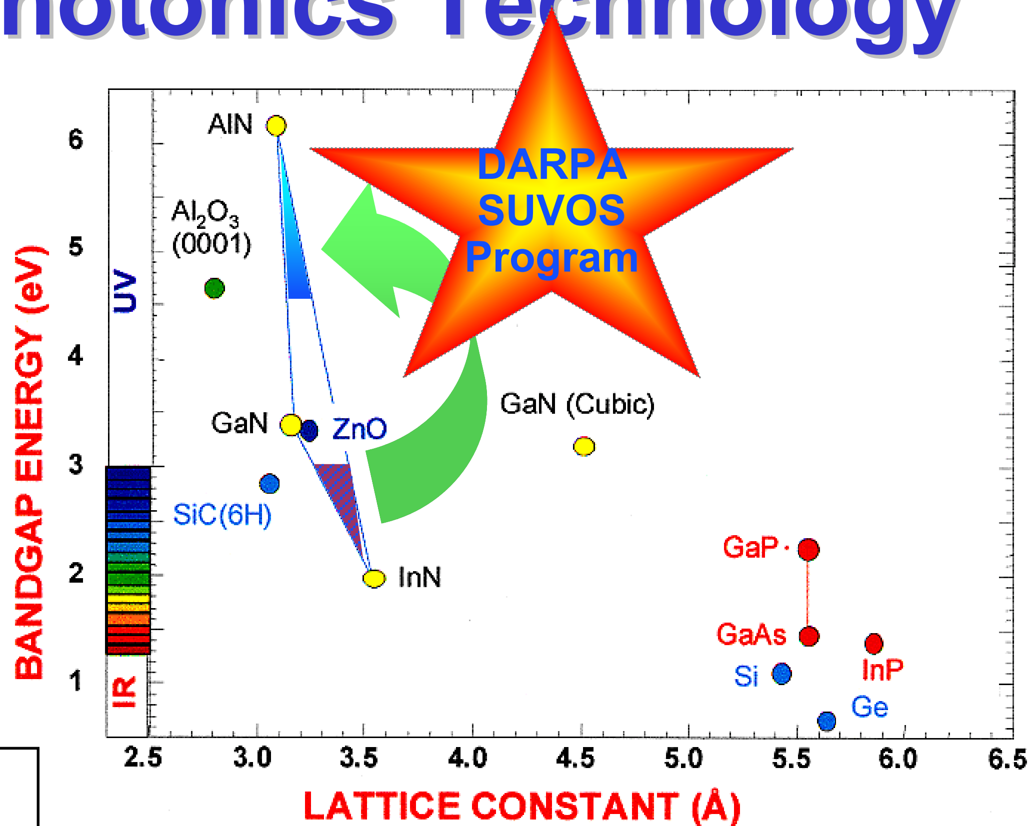
Wide Bandgap Photonics Technology

Program Goals:

- Demonstrate semiconductor UV optical sources (λ = 280 nm).
- Compared to current non-semiconductor approaches
  - Reduce power consumption by 50x
  - Reduce size/weight by >100x



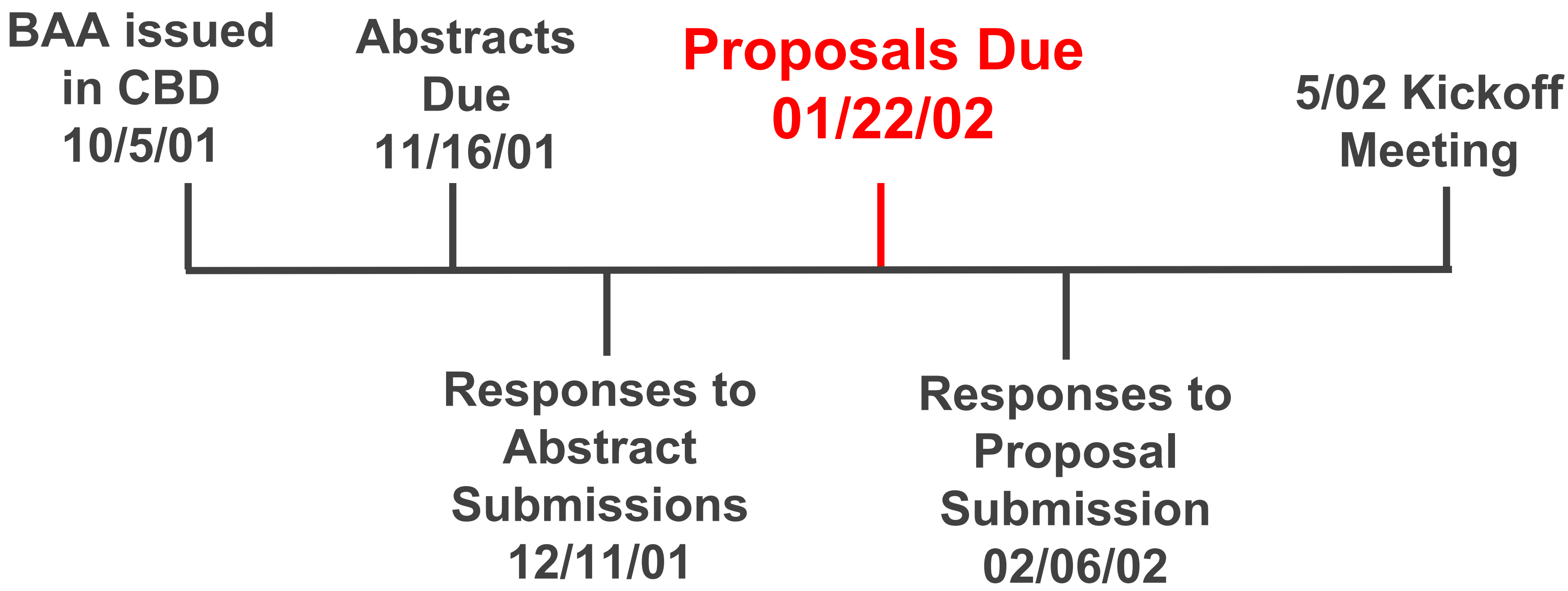
Program Challenges:

- *p*-type conductivity of UV materials
- Device Innovation
  - Suppress non-radiative recombination
  - Epitaxial uniformity and strain management
- Microsystem prototype development

Military Applications:

- ***Biological Agent Threat Warning***
- **NLOS Covert Communications**

BAA Timeline



Thrust Areas

- UV Photonic Materials Development
  - Exploitation of III-Nitride based semiconductors
  - High aluminum content material (280 nm active regions)
  - Epitaxial uniformity
  - Other novel approaches (e.g. organics, phosphors)
- UV Emitters (LED’s and Laser Diodes)
  - Initial development of 340 nm emitters
  - Final goal is 280 nm semiconductor optical sources
  - LED’s and laser diodes of interest
  - OLED’s, field emitters, others
- Testbed Development and Demonstrations
  - Biological agent detection
  - NLOS covert communications

Program Phases

- Phase I Goals (24 Months)
  - Develop UV photonic materials
  - Optoelectronic device innovation
- Phase II Goals (two 12 Month periods)
  - Optimization of UV photonic materials
  - Demonstration of UV optical sources (280 nm)
  - Testbed development and demonstrations
    - Biological Agent Detection
    - NLOS Covert Communications
- Milestones and Metrics
  - Established timelines for demonstrations/deliverables
  - Clearly stated metrics (exit criteria)
    - Acceptable range of performance
    - Highlight “show-stopper” criteria

Vertical Integration of Teams

- Primary DARPA interest is in comprehensive teams to address all program goals.
- Some individual performer efforts considered
- Visit the SUVOS teaming website

Government Lab Involvement

- Do not include gov't labs as part of BAA submission
- Willingness to provide deliverables to gov't labs as designated by DARPA PM.

Evaluation Criteria

- Overall scientific and technical merit
- Potential contribution and relevance to DARPA mission
- Plans and capability to accomplish technology transition
- Offeror's capabilities and related experience
- Cost realism

Performance Goals

- Wavelength: 340nm $\rightarrow$ 280nm
- Devices: LED's and Laser Diodes
- Power: Milliwatts of optical output
- Operation: Pulsed and CW (RT)
- Efficiency: High External Q.E.
- $V_{turn\text{-}on}$: Low voltage
- Lifetime: >10,000 hours

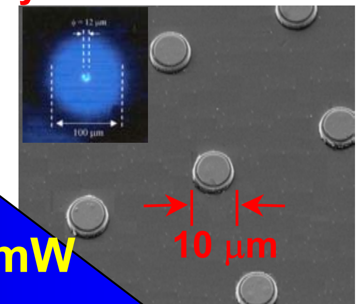
Current Limitations and Program Goal

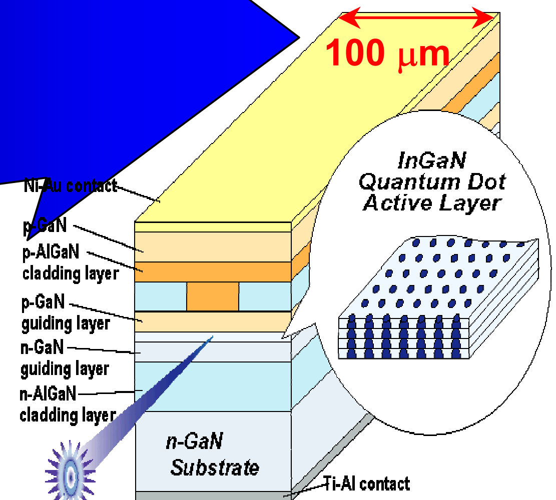
Reduction

- Consumed power: 25 W → 100mW
- Size: 500 cm^3 → 1 cm^3
- Weight: 4 Kg → 2 g
- Cost: $10K → $100

Reduction

Vertical cavity surface emitter arrays





Edge emitters

PROGRAM DELIVERABLES

Non-Line of Sight Covert Comms:

- 280 nm LED's (< 10 mW)
- Transceiver Test bed

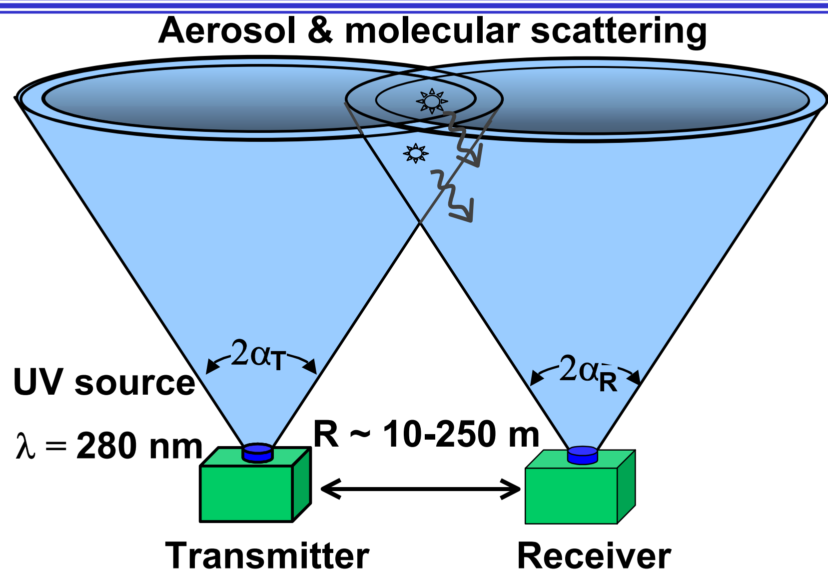
Bio-Detection:

- 280 nm LED's (< 10 mW)
- 340 nm Laser Diodes (< 25 mW)
- Microsystem Test bed

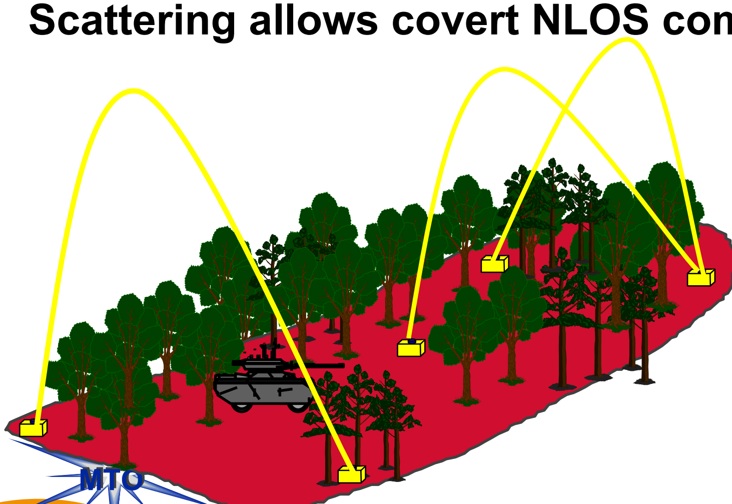
Emitter

Power Source

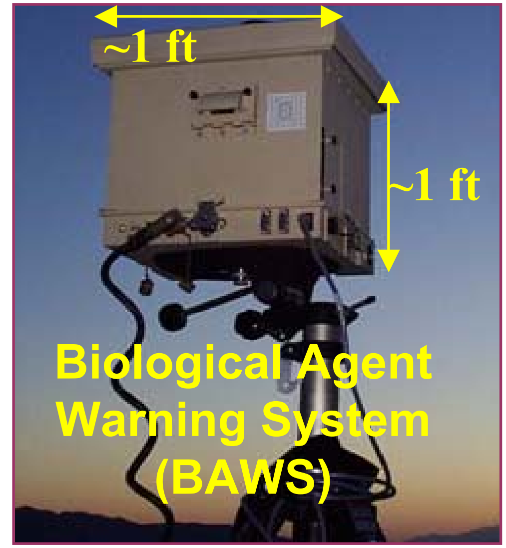
Military Impact

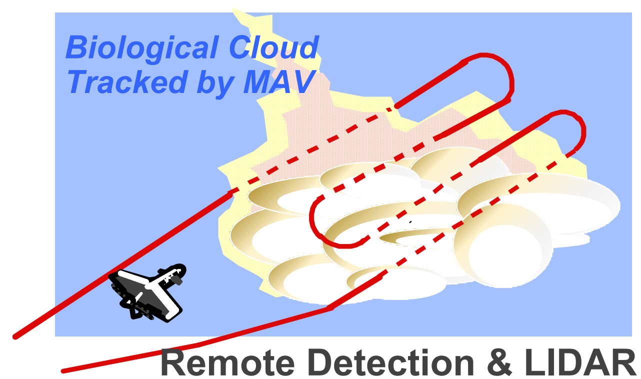


- Transceiver is a chip-scale microsystem
- Scattering allows covert NLOS comms

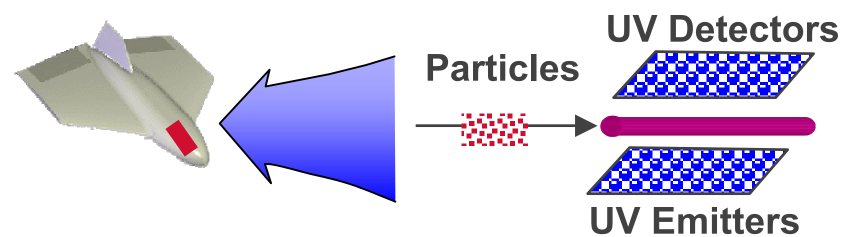


From Shaw et al., 2000





Remote Detection & LIDAR



Technology Nuggets

Challenges | **Solutions**

- *p*-type Conductivity
- Device Innovation
  - Suppress non-radiative recombination
  - Strain management
- Large Band Offsets
  - Reduce turn-on voltage
  - Enhance carrier transport

Program Plan

- **Task 1: UV Materials Development**
  - *p*-type doping (and ohmic contact development)
  - Optical gain (active region development)
  - Band-gap engineered heterostructures

- **Task 2: Device Innovation**
  - 340 nm LED and Laser Diode (NADH)
  - 280 nm LED (Amino Acids, Comms)

- **Task 3: Integration and Demonstration**
  - Transceiver test bed
  - Bio-detection test bed

Task 1: UV Materials Development

- Research Challenges:
  - Improve p-type Conductivity
  - Reduce Operating Voltage
  - Enhance Radiative Efficiency
  - Ohmic contact optimization

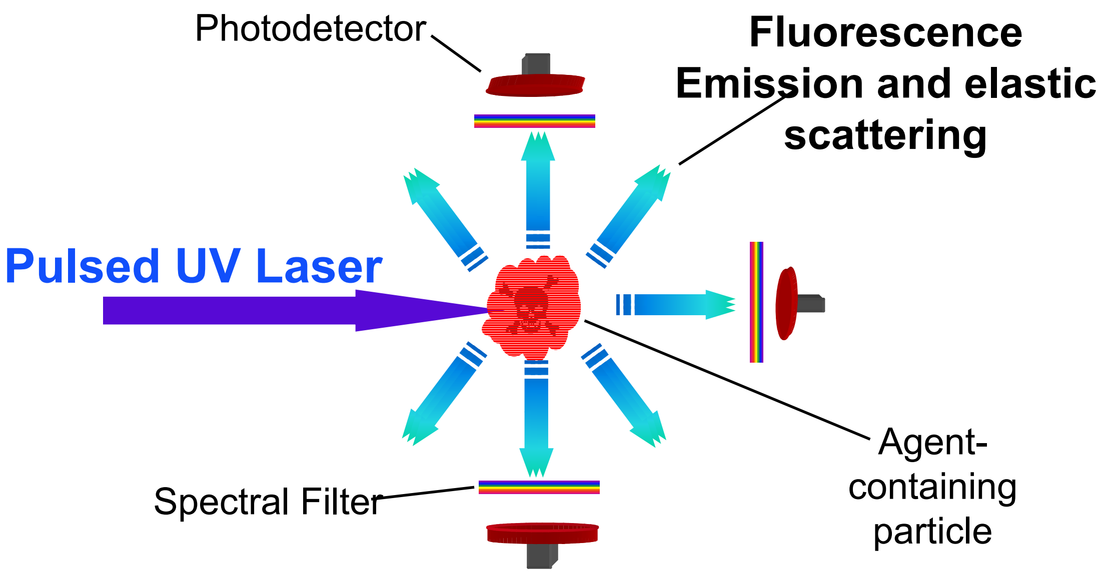
Task 2: Device Innovation

- Research Challenges:
  - Novel structures
  - Cavity Optimization
  - Light Extraction through GaN contact layers
  - Uniformity and reproducibility
  - Current Injection techniques
  - Thermal Management
  - Strain and Cracking

Task 3: Integration and Demonstration

- Research Challenges
  - Transceiver test bed development
  - Biological agent detection test bed
  - Heterogeneous Integration

Laser Induced Fluorescence



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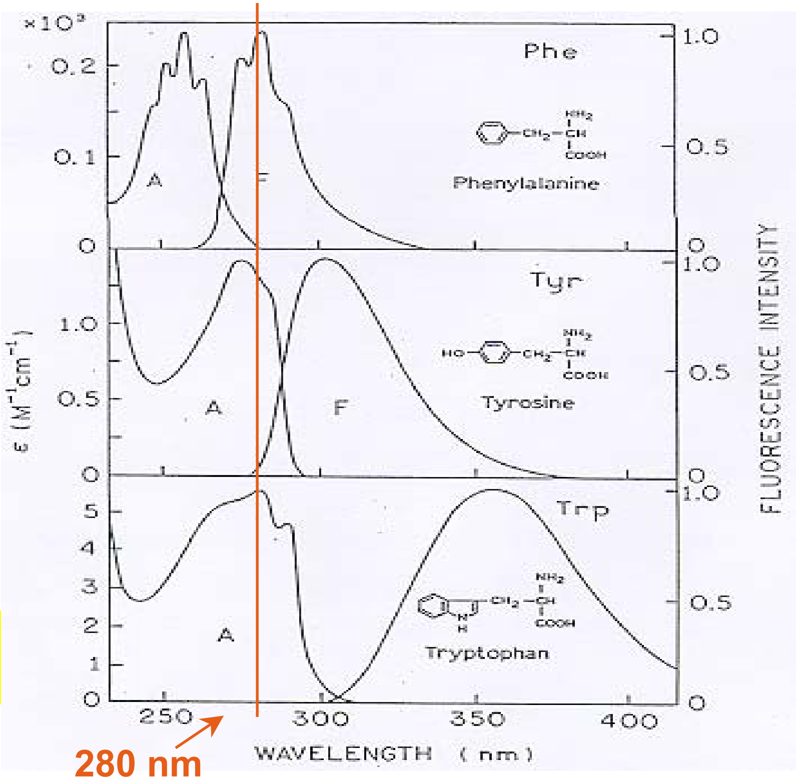
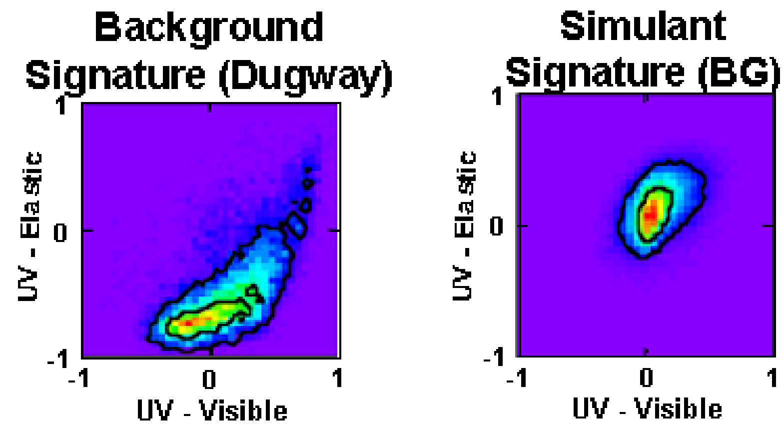
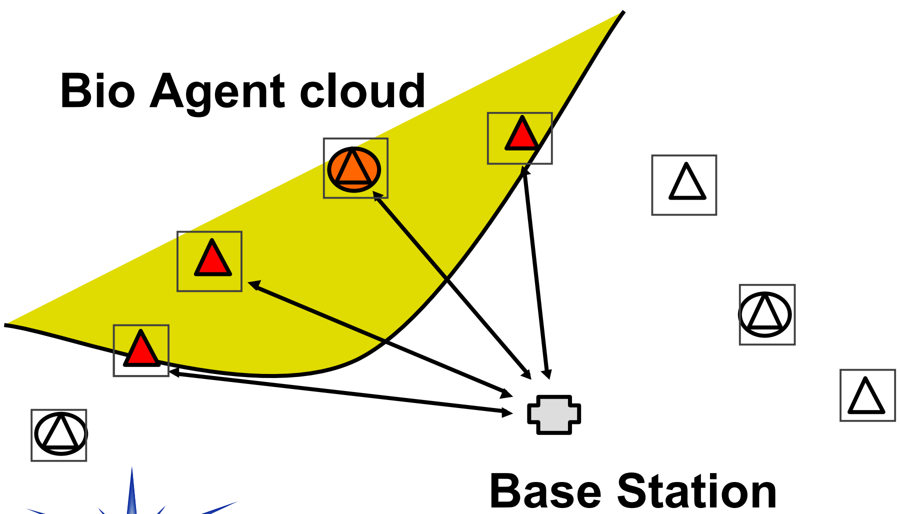
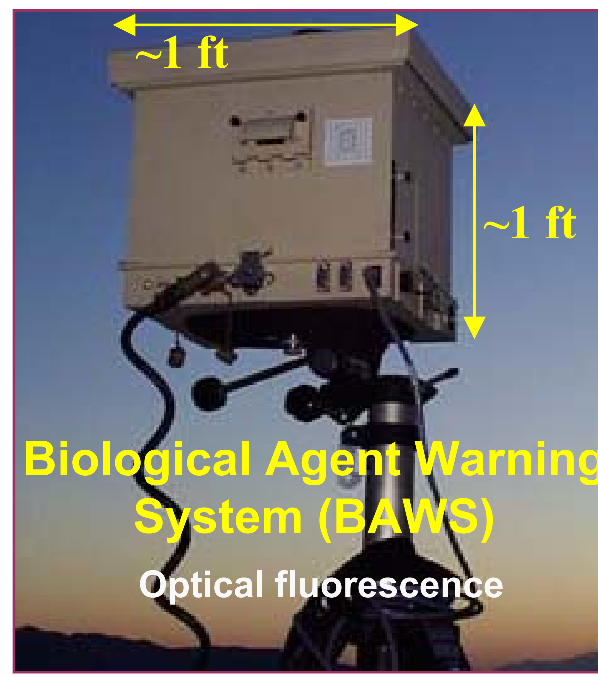


Military Impact (Bio-Sensing)

DoD needs revolutionary technologies to enable the miniaturization of bio-detectors







Future Enabled NBC Applications

Offers greater tactical flexibility to the commander in the field