Active Denial Technology (ADT)

Non-Lethal Weapons Research and Technology Development

Industry Day

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http://jnlwp.defense.gov

Background

- Active Denial Technology (ADT) is the term used to describe technology that uses radio frequency millimeter waves to produce an intolerable heating sensation compelling targeted individuals to instinctively move out of the beam.
- ADT currently exists in two system configurations: one integrated into a HMMWV and the other a containerized version transportable via a tactical truck.
- Extensive safety and effectiveness research and testing has been conducted on existing systems (11,800 exposures).

- The JNLWP is focused on developing and integrating smaller, lighter and lower cost ADT components onto various platforms.

Technical Objectives

- Bioeffects
  - Determine limiting effective spot size(s) for emerging ADT systems
  - Characterize multiple beam effects (simultaneous multiple target exposures)
  - Model thermal effects to predict the efficacy of emerging ADT systems
  - Characterize human effects associated with 220GHz
  - Assess safety of emerging ADT systems
- ADT Hardware:
  - Design and build longer range compact ADT systems
    - 30+ kW scalable compact ADT skid plate demonstrators
  - Enable shoot-on-the-move and instant-on capabilities
  - Integrate compact ADT systems onto various Service platforms for demonstration
  - Develop and demonstrate autonomous solid state mm-wave sources

Relevant Work

- ADT Bioeffects
  - U.S. Air Force Research Lab
  - Focus:
    - Comprehensive study of 94-95 GHz millimeter wave energy safety and effectiveness
    - Assessment of variables that could impact safety and effectiveness
      - Small spot size
      - Multiple beams
      - Implanted medical devices
    - Assessment of effectiveness of full body exposures in field settings
      - RF Effects Registry

Relevant Work

Sample of ADT bioeffects work :

- Chalfin, S., D'Andrea, J.A., Comeau, P.D., Belt, M.E., and Hatcher, D.J. Millimeter wave absorption in the nonhuman primate eye at 35 GHz and 94 GHz. Health Physics, 83(1): 83-90, 2002.
- Foster, K.R., D'Andrea, J.A., Chalfin, S., and Hatcher, D.J. Thermal modeling of millimeter wave damage to the primate cornea at 35 GHz and 94 GHz. Health Physics, 84(6): 764-769, 2003.
- Jauchem, J.R. A Literature Review of Medical Side Effects from Radiofrequency Energy in the Human Environment. Journal of Microwave Power and Electromagnetic Energy, 32 (2): 103-124, 2003.
- Jauchem, J.R. Ryan, K.L., and Frei, M.R. Cardiovascular and thermal responses in rats during 94GHz irradiation. Bioelectromagnetics 20:264-267, 1999.
- Mason, P.A., Walters, T.J., DiGiovanni, J., Beason, C.W. Jauchem, J.R., Dick, J.E., Mahajan, K., Dusch, S.J., Shields, B., Merritt, J.H., Murphy, M.R., and Ryan, K.L. Lack of effect of 94-GHz radio frequency radiation exposure in an animal model of skin carcinogenesis. Carcinogenesis 22: 1701-1708, 2001.
- Nelson, D.A., Walters, T.J., Ryan, K.L., Emerton, K.B., Hurt, W.D., Ziriax, J.M., Johnson, L.R., and Mason, P.A., Inter-species extrapolation of skin heating resulting from millimeter wave irradiation: modeling and experimental results. Health Physics, 84(5): 608-615, 2003.

Relevant Work

Sample of ADT bioeffects work continued :

- Nelson, D.A., Nelson, M.T., Walters, T.J., and Mason, P.A. Skin heating effects of millimeter wave irradiation: Thermal modeling results. IEEE Transactions on Microwave Theory and Techniques 48:2111-2120, 2000.
- Pakhhomov, A.G., Akyel, Y., Pakhomova, O.N., Stuck, B.E., and Murphy, M.R. Current state and implications of research on biological effects of millimeter waves. Bioelectromagnetics 19:393- 413, 1998.
- Ryan, K.L., D'Andrea, J.A. Jauchem, J.R., and Mason, P.A. Radio frequency radiation of millimeter wavelength: Potential occupational safety issues relating to surface heating. Bioelectromagnetics 78: 170-181, 2000.
- Walters, T.J., Ryan, K.L., Nelson, D.A., Blick, D.W., and Mason, P.A., Effects of blood flow on skin heating induced by millimeter wave irradiation in humans. Health Phys. 86(2): 115- 120, 2004.
- Walters, T.J., Blick, D.W., Johnson, L.R. Adair, E.R., and Foster, K.R. Heating and pain sensations by millimeter waves: Comparison to a simple thermal model. Health Physics 78:259- 267, 2000.

Relevant Work

- Compact ADT
  - University of California, Davis
  - Contract No.: N66001-11-C-2003
  - Focus:
    - Design, build and demonstrate 10-kW and 30-kW scalable compact ADT (w-band sheet beam klystron) skid plate demonstrators
    - Fabricate and demonstrate a 40-kW compact ADT (second harmonic gyrotron) capable of producing continuous wave 95 GHz power

Relevant Work

- Planar Scanner Antenna
  - CPI Malibu Division
  - Contract No.: M67854-10-C-7013
  - Focus:
    - Design, develop and demonstrate a 10”-30” ADT planar scanner antenna that can be integrated (flat) into a platform body
    - Provide multiple-beam/target capability
    - Integrate onto Compact ADT demonstrators

Relevant Work

- Solid State ADT Source
  - Raytheon
  - Contract No.: N66001-11-C-2002
  - Focus:
    - Develop, fabricate and demonstrate high efficiency, Gallium Nitride (GaN) Monolithic Microwave Integrated Circuits (MMIC)
    - Enable advanced 95-GHz and 220-GHz solid-state millimeter-wave sources for future ADT systems

Relevant Work

- 6.4kW 95 GHz GaN Solid State ADT Array Skid Plate Demonstrator
  - Co-Funded with Army Research Development and Engineering Center (ARDEC), Picatinny
  - Raytheon
  - Contract No.: H94003-D-0006 via Defense MicroElectronics Agency Contractual Engineering Task, Delivery Order #0166
  - Focus:
    - Develop compact, self-contained, 6.4kW solid state ADT skid plate demonstration system
      - Demonstrate ADT capability at 100+m
      - Achieve Technology Readiness Level 6

Relevant Work

- Thermal Management Phase I Small Business Innovative Research (SBIR)
  - Topic #: Navy102-110
    - Advanced Cooling Technologies, Inc. (M67854-11-C-6506)
    - Allcomp, Inc. (M67854-11-C-6507)
    - International Mezzo Technologies (M67854-11-C-6508)
    - Altex Technologies (M67854-11-C-6509)
    - Thermal Form & Function, Inc. (M67854-11-C-6510)
  - Focus:
    - Design next generation cooling/thermal management system to meet identified system performance specifications relevant to ADT systems and the 30 kW vehicle stopper systems.
- Thermal Management Phase II SBIR (Pending Award)
  - Focus:
    - Fabricate and test cooling/thermal management design.
    - Conduct system analysis and design tradeoffs.

Relevant Work

- ADT Beam Characterization
  - NSWC Dahlgren
  - Focus:
    - Develop capability to measure the power density of 95-GHz systems with high temporal and spatial resolution
      - Power handling: 30 W/cm^2
      - Spatial resolution: ~30mm
      - Temporal resolution: 30 Hz
    - Support JNLWD ongoing ADT efforts with source (spot-size) characterization and beam diagnostics

Relevant Work

Sample of ADT hardware work :

- “Solid State Active Denial Weapons” Brown, et al. 13th Annual Directed Energy Symposium Proceedings (2010)
- “Active Denial Array” Woods and Ketner. *Leading Edge,* Vol 8 (2012)
- “The Active Denial System. A Revolutionary, Non-lethal Weapon for Today’s Battlefield” Levine. National Defense University Technical Report (2009)
- “Solid State Active Denial Technology Demonstrator Program” Robinson. Joint Armaments Conference (2012)

Research & Development Tasks

General types of tasks required for ADT research and technology development:

- System efficacy characterization and modeling, including human subject research
- System injury risk assessment
- Component and peripheral technology development
  - Reduced size, weight and cost
  - Improved efficiency
- Prototype development, testing, and demonstration of longer range ADT systems
- Systems engineering and platform integration studies
- Platform integration

Capabilities

General capabilities and expertise that may be required to execute planned R&D ADT tasks:

- Engineers/Scientists with expertise in physics, electrical engineering, solid state physics, electronics, materials, systems engineering
- Facilities and equipment to build and test prototype systems
- Biomedical researchers with expertise in radio frequency effects
- Accredited institutional controls for bioeffects research:
  - Institutional Review Board (IRB)
  - Institutional Animal Care and Use Committee (IACUC)

Questions?

Please submit questions by 29 June 2012:

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and

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