TCG-V: Power Systems Technology

“The Future of Munitions Batteries”
Workshop
Army Research Laboratory (ARL)
7 December 2016

Anthony Pergolizzi (ARDEC) -- TCG-V Chair
anthony.j.pergolizzi.civ@mail.mil, 973-724-2361
TCG-V Mission, Vision & Goals

- **Mission:**
  - Foster S&T Investments In Munition Power Sources

- **Vision:**
  - Develop the Next Generation of Power Sources
  - Develop Computational Models To Predict Performance Of Power Sources

- **Goals**
## TCG-V Projects

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Lab</th>
<th>Potential/Planned Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Battery Performance</td>
<td>Sandia</td>
<td>DoD Laboratories, Thermal Battery Industrial Base, DoD Prime</td>
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<tr>
<td>Models</td>
<td></td>
<td>Contractors</td>
</tr>
<tr>
<td>Thin Film Thermal Battery</td>
<td>Sandia</td>
<td>Thermal Battery Industrial Base, DoD Prime Contractors, DoD</td>
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<td></td>
<td></td>
<td>Laboratories</td>
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</tbody>
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DISTRIBUTION A: Approved for Public Release. Distribution is unlimited.
TCG-V Impact

• TCG-V Modeling Provides Significant Cost Savings
  – Thermal Battery Designs Can Be Quickly Evaluated
  – Eliminates Iterative Design Process
  – Expands Our Understanding Of How Thermal Batteries Work
• Thin Film Battery Development
  – Potential In Medium & Small Size Munitions
  – Conformal Shape Does Not Require Central Design Space
  – Improved Production Process
  – Improved Performance
    • Faster Rise Times
    • Higher Power & Energy Densities

Affordable -- Advances Technology -- Improves Performance -- Supports Fragile Industrial Base
TCG-V Accomplishments

**SNL:**
- **Thermal Battery Modeling Effort**
  - High Temp Friction Measurements Were Obtained To Feed Model
  - An Apparatus Was Built To Measure Permeability Of Battery Materials
    - Data Collected Will be Used To Feed Coupled Physics Models
  - A Coupled Thermal Electro-Mechanical Single Cell Model Was Demonstrated
  - Thermal, Electrochemical and Two Phase Porous Flow Physics
    - Models Coupled and Demonstrated
  - TABS v4 Was Demonstrated At Spring Review

- **Thin Film Conformal Battery**
  - Successfully Coated and Produced Thin Film Cathode
    - Overcame Early Lamination and Adhesion Issue
  - Successfully Produced Thin Film Separator
TCG-V Transitions

- **SNL:**
  - Thermal Battery Modeling Effort
    - TABS v4 Was Transitioned To DoD
      - 6-7 Active Licenses Tri-Service Applicability
      - Early Attempts To Transition To Industrial Base Unsuccessful
        » Small Cost For Training & Support Remains Underfunded
        » TCG-V Will Continue To Work With Industry Partners
  - Thin Film Battery Conformal Battery
    - Transitions Planned To Industry Either As Full Battery or Components
    - DoD Transitions Planned
TCG-V Accomplishment / Transition / Collaboration Highlights

- Thermal Battery Modeling
  - High Level of Support
  - Reduces Development Cost
  - Good Transition History
- Thin Film Conformal Battery
  - Potential To Reduce Space Claim
  - Supports Smaller Munitions
  - Leverages TCG-X & JFTP
  - Break-Through Technology
    - Currently Limited To Pressed Pellet

TCG-V
- Re-Visit Un-Confined DoD / DOE Needs
- Align Future Modeling Needs w/User Goals

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• Small DoD Munition Power Sources Required
  • Thermal or Liquid Reserve
• Active Batteries Which Have 20+ Years Shelf Life
  • May Not Be Feasible For Significant Time
• Energy Harvestors
  • Lowest Level Of Interest
  • Used By All Services
  • May Be Too Application Specific
## Ordinal Rank Order

<table>
<thead>
<tr>
<th>Ordinal</th>
<th>Technical Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Full Battery Multi-Physics Design Model</td>
</tr>
<tr>
<td>2</td>
<td>Experimental Model Validation</td>
</tr>
<tr>
<td>3</td>
<td>Battery Material Property Discovery</td>
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<tr>
<td>4</td>
<td>TABS Uncertainty Qualification / Component Margin Studies</td>
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<tr>
<td>5</td>
<td>Three Dimensional Battery Models</td>
</tr>
<tr>
<td>6</td>
<td>Modeling Batteries Under Environmental Stresses</td>
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<tr>
<td>7</td>
<td>Incorporate Thin Film Batteries Into TABS Model</td>
</tr>
<tr>
<td>8</td>
<td>Next Generation GUI (Improved User Interface)</td>
</tr>
<tr>
<td>9</td>
<td>Models For Battery Ageing</td>
</tr>
<tr>
<td>10</td>
<td>Abnormal Environmental Modeling (Accidental Fires, etc)</td>
</tr>
<tr>
<td>11</td>
<td>Models For Liquid Reserve Batteries</td>
</tr>
<tr>
<td>12</td>
<td>Models For Primary of Secondary Batteries (Actives, Lithium Ion etc)</td>
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</tbody>
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TCG-V Technical Gap Survey
Observations & Questions

- Modeling Ranks Closely Spaced
- Variations Due To Process Or Actual Ranked Weight?
- Is This The Correct Order?
- How Would DOE Rank?
- Improved User Interface Scored Low
  - Poor User Interface Directly Linked To Transitions and Use
  - Is It That Users Are Happy With Interface As Is?
- How Does Each Task Weigh To LOE and Cost?
• Aging models for Thermal Batteries and components.
• Alternative Thermal Battery header designs.
• Aging models and studies for COTS (or novel) super-capacitors and components
• Non-destructive surveillance of Reserve Batteries (thermal or liquid)
• Include newer materials in models
Questions?