Novel Munitions Power Systems

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PRESENTED BY
Karen Amabile, Power Sources APO
Chris Janow, Power Sources Senior Technology Manager

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Known Issues:

- Energy & power densities of current batteries are limited by dated, insufficient manufacturing techniques that do not meet future user requirements, limiting capability and functionality
- Issues with manufacturing, reliability and functionality

Challenges:

- Alternative energy systems not proven in munitions
- Limited mission times for thermals due to heat losses
- Small, high energy/high density thermals do not exist
- Corrosive, moisture sensitive electrolytes for liquid reserves impact producibility

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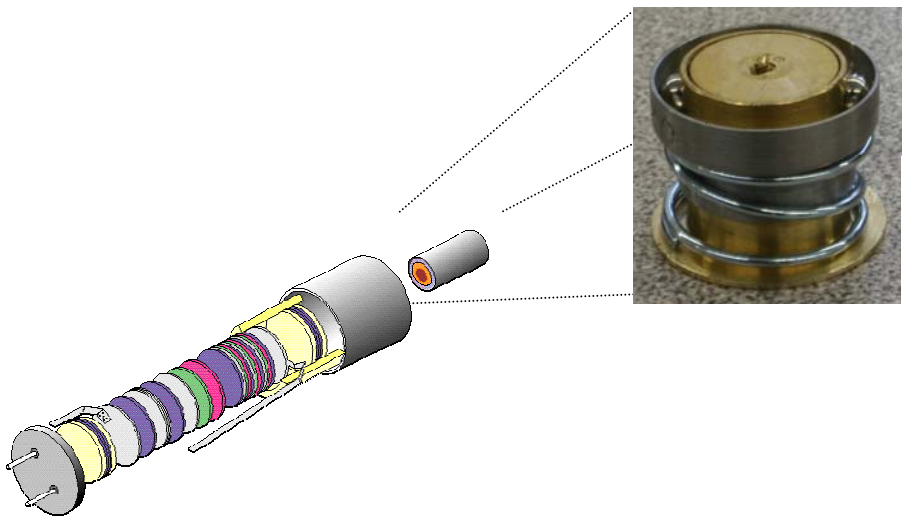
Objective:

- To develop advanced, affordable, on-board gun-fired munitions power source technologies with increased energy and power densities, reduced volume and weight, increased mission time & improved extreme temperature performance.



Technical Approach

- ✓ Improve Thermal Batteries by novel thermal management techniques that will result in longer lasting yet smaller batteries
- ✓ Improve Liquid Reserve Batteries by development of new organic electrolytes that will lead to higher production throughput and lower costs and catalyzed cathodes that provide higher power and energy densities
- ✓ Develop new types of energy harvesters to supplement and reduce the dependence on batteries ("Energy Hybrid Systems")

Applications:

- ***Excalibur***
- ***SDF***
- ***Common Missile***
- ***Rockets (e.g. MLRS)***
- ***Next Generation PGMM***
- ***MOFA***
- ***ETF for Mortars***
- ***Precision Guided Kit***
- ***Supersonic Projectiles***

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Technology drivers:

- *Affordable & producible*
- *Higher energy & power density*
- *Reduced volume & weight*
- *Improved energy management & optimization*

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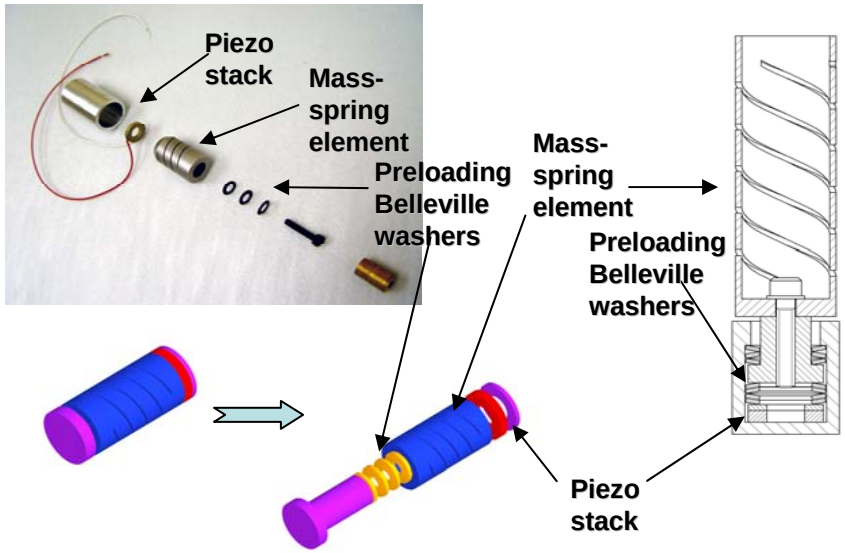
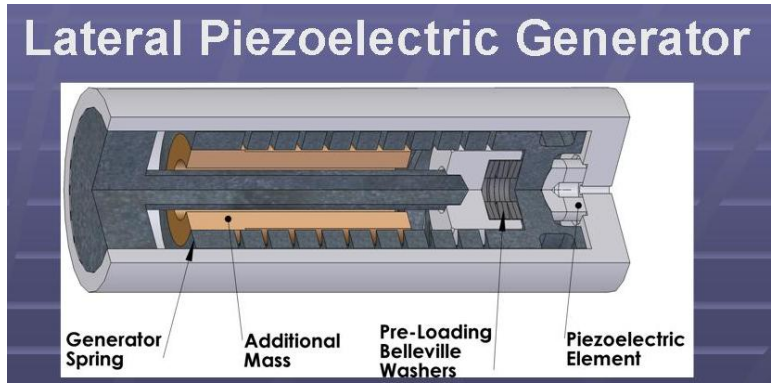
➢ *Thrust Area #1 Hybrid Energy Systems (HES):*

- ❖ Bring a systems approach to the management of power requirements throughout the mission profile of future advanced munitions
- ❖ Increase munitions energy density, mission times and functionality, to decrease their cost and improve the munitions power system reliability, manufacturability and future application interchangeability~ "*scalable power systems"*
- ❖ Develop new types of energy harvesters to supplement and reduce the dependence on batteries ("Hybrid Energy Systems").
- ❖ Convert and combine energy in various forms that is resident in the ballistic environment of gun fired munitions.

❖ Piezoelectric Generator





- Harvests mechanical energy naturally resident in projectile using firing shock and vibration generated during flight
- Converts mechanical energy into electrical energy using piezoelectric materials
- They can use axial or lateral motion for harvesting
- These are compact designs of approx .75” diameter and 1.25” length
- They are very safe and cannot generate power until fired.
- The shelf life well exceeds 20 yrs.

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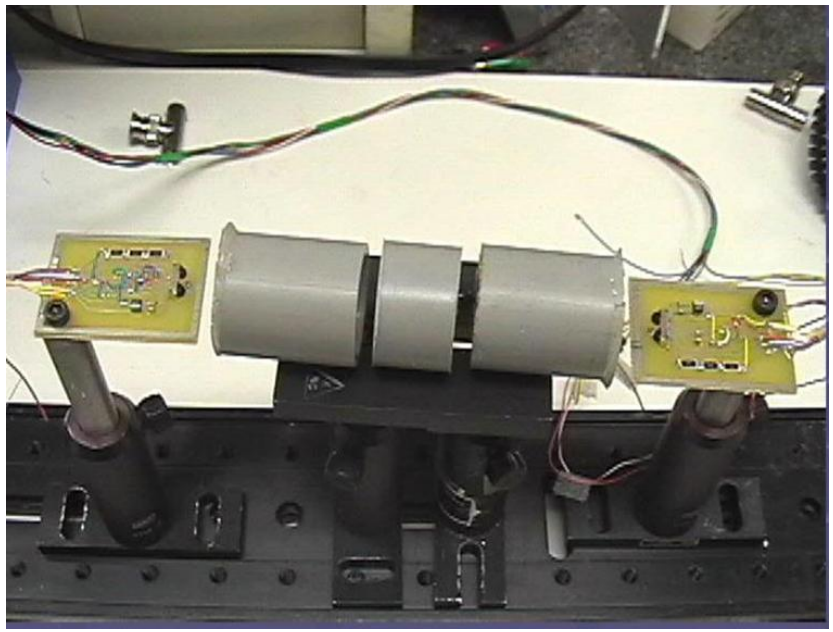
❖Optical Carrier

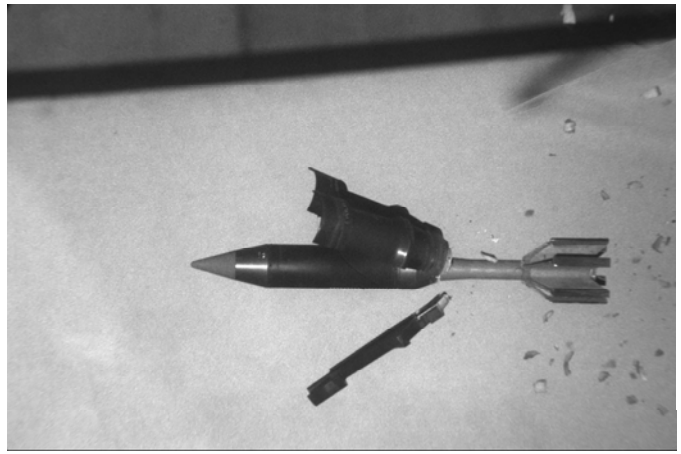
- *Uses near-infrared laser to transmit data and/or power simulataneously*
- *Developed for low cost and low power communication within a round*
- *First use of a "guided" free space optical communication network for munitions*
- *Uses an industry standard IrDA serial communication platform*
- *Data transfer rate of 4 to 16 Mb/s*
- *EMI immunity*

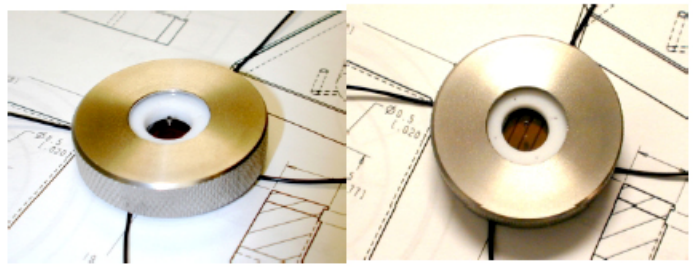


- ✓ ***High G tolerance***
- ✓ ***Very low cost***
- ✓ ***Data and power transmitted through window to munitions' exterior***
- ✓ ***Power transfer of 1J in less than 1/10 second***

❖ Successful Completion of HES Flight Tests in 4QFY07

- ✓*Integrated, prepared and successfully fired three M830A1 rounds at APG with HES components*
- ✓*Proved survivability and demonstrated functionality of Hybrid Energy Systems components*
- ✓*Proved survivability and demonstrated functionality of a conformal thermal battery & nano-reserve battery*





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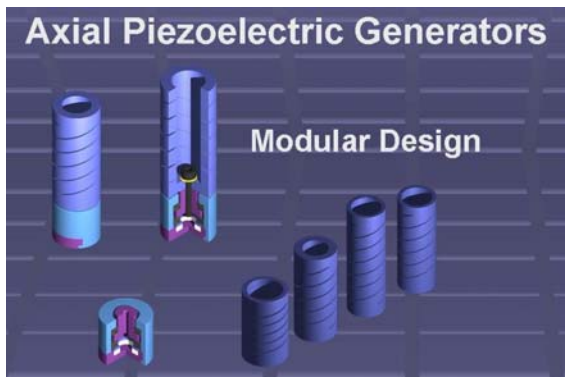
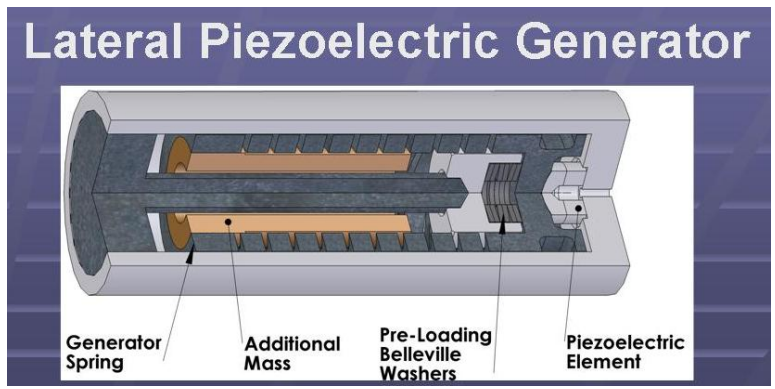
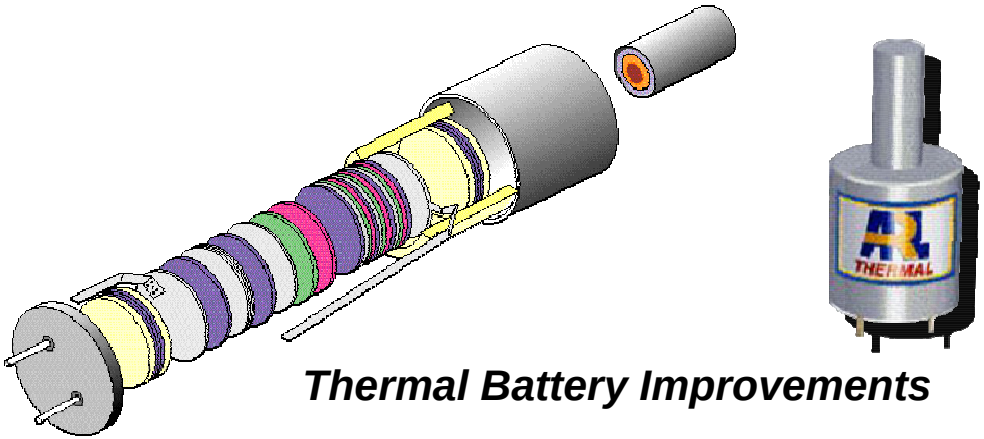
❖Demonstrated Piezoelectric Generator as TRL 7 component

- ✓Built & tested various types of energy harvesters, several types of designs to be mounted axially and radially for flight tests to demonstrate energy harvesting in tri-axial configuration
- ✓These components each have a novel method of harvesting energy
- ✓Components were launched in excess of 35K G's & survived
- ✓First time converted energy using piezoelectric harvester at over 30% efficiency
- ✓Satisfied the 20 mW ATO requirement

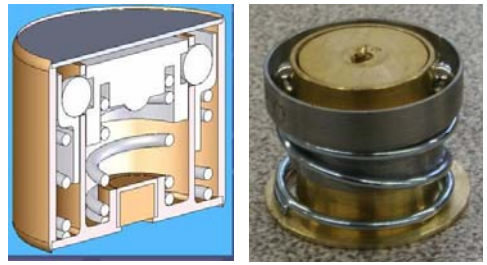




➢ Thrust Area #2 Thermal Battery Improvements



Thermal Battery Improvements



Miniature Igniter

- **Focus on thermal battery heat management and novel insulation materials to increase energy density and runtime.**
- **Evaluate the effects of gas gettering which is dispersed throughout the layers of thermal battery insulation to increase runtime.**
- **Develop battery prototypes with higher energy densities in a smaller volume that meets maximum time of flight requirements**
- **Miniature igniter utilizes firing acceleration and through a mechanical means initiates the ignition system required to activate a thermal battery**

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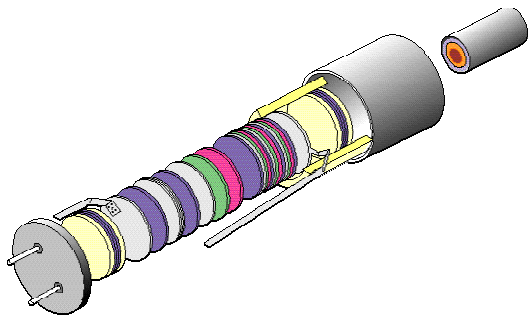
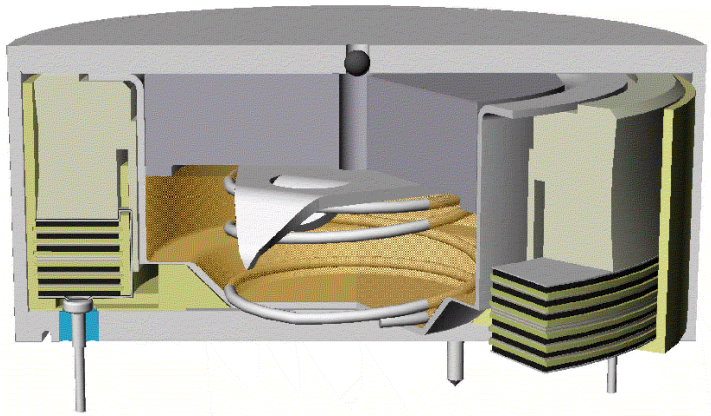
- **Demonstrated Improved Thermal Battery as a TRL 5 component in 4QFY07**
- **Preparation to demonstrate Thermal Battery enhancements during Flight Tests at YPG in 4QFY08 to achieve TRL 7**
  - ✓ Achieved 30% increase in runtime by sidewall heating providing better heat containment with novel insulation material & sidewall heating
  - ✓ Demonstrated significant increase in runtime of thermal battery with higher number of heat pellets
  - ✓ Demonstrated certain metallic gas getters which improve battery run-time



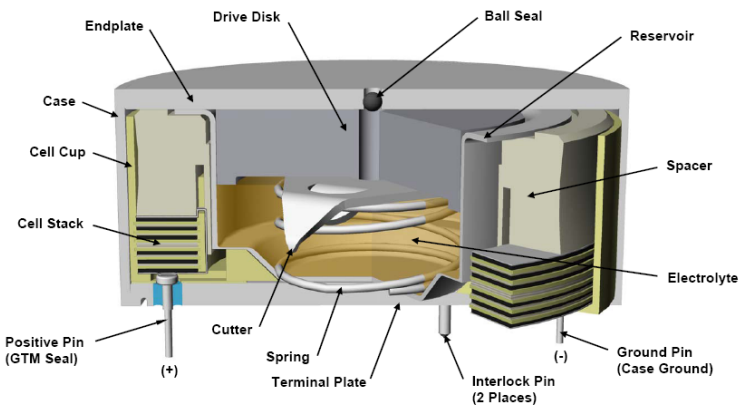
➢ Thrust Area #3: Liquid Reserve Batteries

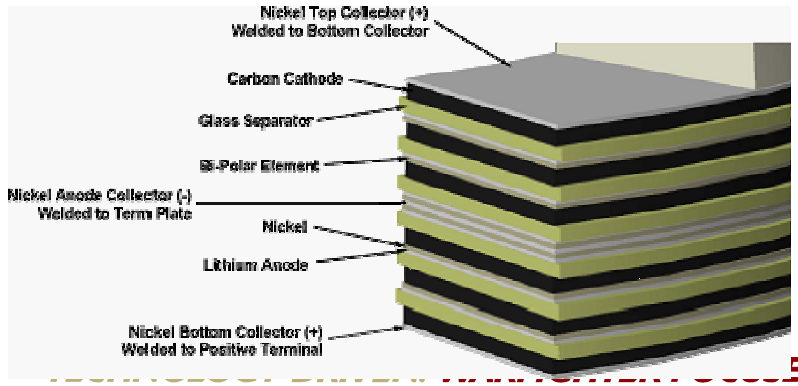


- ❖ **Develop an organic-based liquid reserve battery that would replace the extremely corrosive electrolyte that is very costly to produce which will lead to improved producibility**
- ❖ **Increase the power and energy density while providing aging and stability improvements to the lithium based systems**
- ❖ **Improve Liquid Reserve Batteries by development of catalyzed cathodes that provide higher power and energy densities.**

➢ Liquid Reserve Batteries

- ❖ Developed organic based electrochemistry: down selection of high-performing organic electrolyte of LiBF4 in *g*BL-DME demonstrated performance and increased stability of 3.6V cathode/electrolyte system
- ❖ Optimized Teflon content in MnO2 cathode has shown 60% increase in cell runtime.
- ❖ Developed and prototyping of battery design configuration to meet battery performance requirements for higher production consistency
  - ❖ High rate oxyhalides system shown over 45% increased runtime by the inclusion of catalyst additives to liquid reserve battery electrochemistry.





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- **Path Forward**
  - Combine harvested energy with stored chemical energy reducing the dependency on current method of using solely batteries in munition systems
  - To provide efficient, continuous power systems for military application to power munitions, rockets and missiles by combining harvested energy with electrochemical technologies in reserve battery systems