Project Overview: Year 1

Center for Radiation Engineering and Science for Space Exploration
(CRESSE)

Dr. Richard Wilkins, Director

NASA Technical Review Committee
Reverse Site Visit
Johnson Space Center
August 13, 2009
CRESSE Year 1 Overview: Time of transition

Accomplishments over the past months:

- New equipment purchased:
  - Delivered: Computer cluster for interaction modeling (Aghara), Hydraulic press for composite fabrication (Zhou), Lunar Regolith (350 kilograms!!), Computer controller for parametric analyzer for electronics (Wilkins).
  - Ordered: Tissue equivalent proportional counter (Gersey), NIM system for dosimetry (Gersey).
  - In the process: Radfets for dosimetry and electronics (Wilkins & Gersey).

- Placed seven undergraduate student at JSC for summer interns; hired five graduate students.

- Graduate students for materials efforts – working hard on lunar regolith composites.

- Hired 1 Post-doc (materials), hiring another (interaction modeling).

- Brad Gersey promotion application complete.

- Three refereed papers published or in press.

- CRESSE booth at the 2009 Nuclear and Space Radiation Effects Conference, along with attendance at four other international conferences.

- CRESSE Webpage published by PVAMU:

- Lab and office space renovations continue.
Research Program Overview

Center for Radiation Engineering and Science for Space Exploration (CRESSE)

- Radiation Dosimetry
- Rad-Hard Electronics
- Multi-functional Materials
- Radiation Interaction
- Radiation Environment
- Expertise

- Experiment
- Modeling
- Radiation Detection and Dosimetry Systems

- Benchmarking Codes
- Materials Evaluation
- Radiation Testing
- Radiation Biology
- Deliverables

- New Instruments
- New Endpoints
- New Materials
- Applications

Outcomes

Safer, More Reliable Space Missions

- New Materials
- New Endpoints
- New Instruments

- Radiation Environment
- Radiation Interaction
- Multi-functional Materials
- Rad-Hard Electronics
- Radiation Dosimetry

Center for Radiation Engineering and Science for Space Exploration
Sustainability Efforts during Year 1

• One successful NASA SBIR Phase I, Phase II submitted for $188,000 for two years. Concerns composites for radiation shielding.

• Completed contract with Boeing Space Exploration for proton testing for the Constellation Program. K. Allums was helpful to us on this!

• Dr. Aghara has a three year contract with Langley Research Center to Monte Carlo perform radiation modeling.

• Dr. Zhou (PI) just received a grant from the Department of Education to integrate nanotechnology into the College of Engineering curriculum.

• Dr. Wilkins is collaborating with UT-Dallas and Purdue on proposal to the Defense Threat Reduction Agency on radiation effects on quantum circuits.
These activities will overlap for a time.

<table>
<thead>
<tr>
<th>CRESSE Milestones and Performance Goals</th>
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<tr>
<td><strong>Research Phases:</strong></td>
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<tr>
<td><strong>Expand Capabilities</strong></td>
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<td><strong>Prove-in systems</strong></td>
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<td><strong>Radiation Experiments</strong></td>
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<td><strong>for Exploration</strong></td>
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<td><strong>Year 1</strong></td>
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<tr>
<td>Enhance capabilities in dosimetry and modeling: new equipment, new hardware/ software</td>
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<td>Conduct first radiation experiment with detectors.</td>
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<td>Design target testbed</td>
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<td>Hire post-doc</td>
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<td>Attend 5 conferences, present at 2</td>
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<td>Publish 2 refereed papers on prior data.</td>
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<td>Engage 7 undergraduates, 7 graduate students (at least one Ph.D. student)</td>
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<td><strong>Year 2</strong></td>
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<tr>
<td>Enhance capabilities in materials and electronic testing</td>
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<td>Model detector systems and experimental testbed during initial integration and testing.</td>
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<tr>
<td>Conduct first radiation experiments on electronics.</td>
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<td>Build first model of target testbed</td>
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<td>Publish 4 refereed papers</td>
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<td>At least one new contract and one research grant leveraged.</td>
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<tr>
<td>Engage 7 undergraduates, 7 graduates (at least one additional Ph.D. student)</td>
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<td>2 undergrads into grad school, one master’s degree graduates.</td>
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<td><strong>Year 3</strong></td>
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<tr>
<td>Conduct first radiation experiment with new detector system.</td>
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<td>Conduct initial experiments with Model 1 target testbed.</td>
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<td>Use modeling results to improve understanding of radiation detector responses.</td>
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<tr>
<td>Attend 6 conferences, present at 4, 2 student presentations</td>
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<tr>
<td>Publish 6 refereed papers</td>
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<tr>
<td>At least two new contracts and one research grant leveraged.</td>
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<td>New research staff added based on leveraged funds.</td>
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<tr>
<td>Engage 7 undergraduates, 8 graduates (at least three additional Ph.D. students)</td>
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<td>4 undergrads into grad, two master’s degree graduates.</td>
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<td><strong>Year 4</strong></td>
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<tr>
<td>Conduct first experiment on detector system with rad-hard electronics.</td>
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<td>Complete target testbed for both lunar and Martian simulation.</td>
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<tr>
<td>Complete modeling of experimental test bed. Use radiation detector results to improve detector characterization models.</td>
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<td>Attend 6 conferences, present at all 6, at least half student presentations.</td>
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<tr>
<td>Publish 8 refereed papers</td>
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<tr>
<td>At least two new contracts and two research grants leveraged.</td>
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<tr>
<td>New research staff added based on leveraged funds.</td>
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<tr>
<td>Engage 9 undergraduates, 8 graduates (at least three Ph.D.)</td>
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<td>4 undergrads into grad, three masters and one Ph.D. student graduate.</td>
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<td><strong>Year 5</strong></td>
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<tr>
<td>Conduct a series of experiments with new detector system and modular target testbed.</td>
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<td>Integrate results from experimental testbed and radiation detector modeling into a virtual experiment model.</td>
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<td>Deliver demonstrator to NASA tested radiation detector system with high TRL.</td>
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<td>Attend 8 conferences**, present at all, at least half student presentations.</td>
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<td>Publish 10 refereed papers</td>
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<tr>
<td>At least three new contracts and three research grants leveraged.</td>
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<tr>
<td>Engage 7 undergraduates, 7 graduates (3 Ph.D.)</td>
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<tr>
<td>4 undergrads into grad, four masters and two Ph.D. students graduate.</td>
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Review by NASA Tech Review Committee and External Advisory Panel each year.

** Ph.D. students to be supported by leveraged funds beyond the end of Year 5.

** Leveraged funds will support additional travel to professional conferences.
Year 1 assessment according to goals and milestones in the original proposal:

- Enhance capabilities in dosimetry and modeling: new equipment, new hardware/software.
  ✓ Status: New cluster purchased and installed; TEPC and NIM systems ordered. 
  Plan: New detector hardware expected Fall 2009, beam time reserved at Loma Linda, to be proposed at NSRL for Spring-Summer 2010.

- Conduct first radiation experiment with detectors.
  ✓ Status: First beam experiment to take place next week at LANSCE.
  Plan: LANSCE experiment will conduct experiments on prototype discussed below. Loma Linda experiment to use “Mark I” standard BERT & ERNIE.

- Design target testbed.
  ✓ Status: Prototype design complete, initial lunar regolith plates and CO$_2$ (simulate Martian atmosphere) scheduled to be part of the LANSCE experiment. 
  Design of “Mark I” standard BERT & ERNIE underway.
  Plan: Complete Mark I by end of year (2009).
Year 1 assessment according to goals and milestones in the original proposal (cont.):

- Hire post-doc.
  - Status: Dr. Pendleton hired to supervise materials group regolith composite fabrication.
  - Plan: New Ph.D. level researcher (Dr. Hu) to be hired for interaction modeling (September 2009 start).

- Attend 5 conferences, present at 2.
  - Status: More than 5 international conferences were attended. Drs. Zhou and Saganti presented at two of the conferences. Dr. Wilkins also presented at Texas Academy of Science, March 2009.
  - Plan: Students and Dr. Pendleton to present papers at the NSBE Aerospace Conference in Fall 2009.

- Publish 2 refereed papers on prior data.
  - Status: At least three papers published or in-press in *Radiation Research, Nuclear Instruments and Methods B*, and *Journal of Physical Chemistry C*.
  - Plan: At least one paper to be submitted to IEEE Transactions in Nuclear Science by end of September 2009.

- Engage 7 undergraduates, 7 graduate students (at least one Ph.D. student)
  - Status: 7 undergraduates hired to participate in JSC internships for Summer 2009; five graduate students currently working in materials and dosimetry.
  - Plan: Recruit Ph.D. student(s) ASAP.
Refereed Papers

- “Biological effects of high-energy neutrons measured in vivo using a vertebrate (Oryzias latipes) model”, W. Kuhne, B. Gersey, R. Wilkins, H. Wu, S. Wender, and W. Dynon, accepted for publication in Radiation Research, May 2009.
  In collaboration with Honglu Wu at JSC.

  In collaboration with a number of investigators at JSC.

  In collaboration with the Boeing Company and JSC.

  In collaboration with Langley Research Center.

These show a strong integration with NASA and NASA contractors.
BERT & ERNIE Update

- Lunar regolith delivered.
- Prototype lunar regolith panels fabricated.
- New hydraulic press delivered and being installed.
- Prototype experiments to be conducted at Los Alamos next week.
- Proton experiments planned in December 2009 for student thesis work (Loma Linda).

Martian and Lunar regolith systems called: Bioastronautics Experimental Research Testbeds for Environmental Radiation Nostrum Investigations and Education (BERT and ERNIE)
External Advisory Committee (as appeared in the original proposal):

<table>
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<tr>
<th>EAC Member</th>
<th>Title/Affiliation</th>
<th>CRESSE Contribution</th>
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<tbody>
<tr>
<td>Dr. Kimberly Allums</td>
<td>Radiation Effects Engineer, ERC, Inc., NASA Johnson Space Center.</td>
<td>Radiation testing for the NASA Constellation Program, former student researcher at CARR, minority pipelines to advanced degrees.</td>
</tr>
<tr>
<td>Dr. William Atwell</td>
<td>Boeing Technical Fellow, The Boeing Company, Space Exploration, Houston, TX</td>
<td>Expertise on radiation modeling and its application to space exploration.</td>
</tr>
<tr>
<td>Dr. Thomas Borak</td>
<td>Professor, Department of Environmental and Radiation Health, Colorado State</td>
<td>Extensive expertise in radiation dose and dosimetry instrumentation.</td>
</tr>
<tr>
<td>Dr. Les Braby</td>
<td>Research Professor, Department of Nuclear Engineering, Texas A&amp;M</td>
<td>Radiation instrumentation for over 30 years; built dosimetry instruments for human flights.</td>
</tr>
<tr>
<td>Dr. Yves Chabal</td>
<td>Chair, Department of Material Science and Engineering; Professor, Department of Electrical Engineering, University of Texas - Dallas.</td>
<td>Pipelines for advanced STEM degrees; new materials and devices for space exploration.</td>
</tr>
<tr>
<td>Dr. Mark Shavers</td>
<td>Radiation Scientist, Space Medicine Group, Wyle &amp; Associates, Houston, TX</td>
<td>Radiation risk assessment for astronauts; radiation instrumentation; future workforce planning</td>
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</tbody>
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Changes:
- Kim Allums now a member of the TRC.
- Tom Borak has retired.
- Have invited Dr. Dan Davis at TAMU to participate. Aerospace engineer in materials, interested in minority pipelines in engineering and science.
- Invited Dr. Ellie Blakely, Berkley National Labs, to broaden expertise in the life sciences. (Accepted)
- Need new “electronics” member.
External Advisory Committee (EAC):

Duties & Expectations:
Members will be asked to review CRESSE activities and provide feedback to the investigators on:

- Progress and quality of CRESSE research.
- Relevance of the research to NASA missions.
- Relevance of the research to the aerospace community.
- Trends in engineering, science and technology that may impact the CRESSE research and mission.
- Student pipelines to advanced degrees of importance to NASA.

The members will receive CRESSE reports and be invited to participate either personally or electronically in an annual meeting where investigators will brief EAC members on CRESSE activities and plans.

The first annual meeting is being planned for September 2009 at PVAMU.

Dr. Wilkins is working with Dr. Shavers (current de facto chair) on arrangements for the meeting.
CRESSE Electronics Research

Primary Investigator: Wilkins

- Guiding principle: Assure mission reliability & safety
- Goal: Maximize TRL level of CRESSE research instruments
- Objective: Provide NASA & contractors with radiation effects data from realistic environments

Mechanism for maximizing TRL:

External Inputs:
- Existing literature
- Databases
- Personnel in ESMD

Internal Inputs:
- Environmental & interaction models
- Instrumentation requirements

Input from Allums et. al.

Process:
- Selection of devices for testing.
- Radiation experiments with CRESSE testbeds.
- Integration of devices in electronic systems developed for CRESSE instruments.

Outputs:
- Radiation data on relevant devices.
- Higher TRL for CRESSE researched instruments.

Feedback based on data from experiments.
Starting point for electronics effort: RadFETS:

- Devices DESIGNED for radiation sensitivity – Appropriate first choice device to be used with BERT & ERNIE.
- Radiation response well characterized.
- Excellent research opportunity for tissue and silicon dosimetry.
- Excellent candidate for personal space dosimeters for astronauts.

Commercially Available

Small Size

Straightforward “readout” and calibration.
Experimental Plan for DUTs with BERT & ERNIE:
1. RadFET and Si proportional counter. – Radiation effects on RadFETs understood, comparisons of Si and tissue dosimetry.
2. Prior tested discrete devices – chosen to avoid lot to lot variations.
3. Prior tested integrated circuits.
4. Prior tested system
5. New devices of interest to NASA.

Systematic approach will demonstrate the utility of BERT & ERNIE for understanding the radiation response of electronics on planetary surfaces.