Appendix A

Workscopes for Program and Mission Support – University Only

Program Supporting: Fuel Cycle Technologies

Separations and Waste Forms (FC-1)

(Federal POC – Jim Bresee & Technical POC – Terry Todd)

This program element develops innovative methods to separate reusable fractions of used nuclear fuel (UNF) and manage the resulting wastes. These technologies, when combined with advanced fuels and reactors, form the basis of advanced fuel cycles for sustainable and potentially growing nuclear power in the U.S. The campaign supports research through the full range of use-inspired basic research through process engineering with multi-institutional, multi-disciplinary teams comprised of national laboratory researchers with full radioactive laboratory capabilities teamed with industry and university researchers. Priority research efforts revolve around achieving near-zero radioactive off-gas emissions; developing a simplified, single-step recovery of transuranic elements; and significantly lessening the process wastes. Exploratory paths include developing fundamental understanding of separation processes and waste form behavior; understanding the underlying separation driving forces; exploiting thermodynamic properties to effect separations; elucidating waste form corrosion mechanisms; and investigating novel new approaches to used fuel treatment and associated waste forms with significantly improved performance. Key university research needs for separations and waste forms campaign include:

FC-1.1: Electrochemical Separations

- Development of fundamental understanding of advanced electrochemical separation methods for the separation of transuranic elements (Np, Pu, Am, and/or Cm) including the development and validation of predictive modeling approaches based on fundamental data rather than empirical approaches;

FC-1.2: Advanced Separations Methods

- Development of novel “out of the box” separation methods that have the potential of significantly reducing complexity and cost of processing fuel while reducing proliferation risk and waste generation;

FC-1.3: Advanced Waste forms

- Innovative waste forms with orders of magnitude higher chemical durability and equal of lower processing costs compared to currently-employed waste forms such as borosilicate glass particularly for long-lived fission products such as iodine-129 and technetium-99 and for grouped fission products high-level waste;
- Fundamental understanding of waste form performance over geologic time scales; particularly for multi-phase oxide waste forms.

Advanced Fuels (FC-2)

(Federal POC – Frank Goldner & Technical POC – Kemal Pasamehmetoglu)

This program element develops advanced nuclear fuel technologies using a science-based approach focusing on developing a microstructural understanding of nuclear fuels and materials. The science-based approach combines theory, experiments, and multi-scale modeling and simulation to develop a fundamental understanding of the fuel fabrication processes and fuel and clad performance under irradiation. The objective is to use a predictive approach to design fuels and cladding to achieve the desired performance (in contrast to more empirical observation-based approaches traditionally used in fuel development).

The advanced fuels program conducts research and development of innovative next generation LWR and transmutation fuel systems. The major areas of research include, enhancing the accident tolerance of fuels and materials, improving the fuel system's ability to achieve significantly higher fuel and plant performance, and developing innovations that provide for major increases in burn-up and performance. The advanced fuels program is interested in advanced nuclear fuel and materials technologies that are robust, have high performance capability, and are more tolerant to accident conditions than traditional fuel systems. Key university research needs for this activity include:

FC-2.1: Characterization and Instrumentation

Development of novel fuel and cladding material characterization techniques and/or innovative in-pile instrumentation that can be applied to irradiated nuclear fuels and materials that support the goal of understanding the behavior of and predicting the performance of the nuclear fuel system at a microstructural level.

FC-2.2: Separate Effects Testing To Support Model & Material Science Development

Developing and conducting separate effects tests to provide fundamental physical and chemical data at a micro-structural level that will support development of predictive, physics-based fuels performance models. These tests should consider: 1) helping validate lower-length scale and engineering scale models (e.g., MARMOT and BISON); and, 2) furthering the understanding of mechanistic material behavior in fuels, including how relevant microstructures affect the mechanical, thermal, and chemical performance.

Nuclear Materials Control and Instrumentation (FC-3)

(Federal POC – Daniel Vega & Technical POC – Mike Miller)

This program element develops technologies and analysis tools to support next generation nuclear materials management and safeguards for future U.S. fuel cycles. This includes both extrinsic measures and safeguards over-laid on a nuclear energy system, as well as the intrinsic design features incorporated into system design. New technologies and approaches to in-facility accounting and control/safeguarding of nuclear materials will be pursued under this research area. This research topic will also pursue nano-technology and nano-materials as they relate to sensors, detectors, and nanoparticle signatures, and other advanced measurement techniques that could complement the ongoing measurement program. Key university research needs for this activity include:

FC-3.1: Sensors and Instrumentation

New and improved detector systems and sensor materials that can be used to increase the accuracy, reliability, and efficiency of nuclear materials quantification and tracking from the perspective of the operator or state-level regulator. Such systems could include new neutron methods, spectroscopic analysis, chemical, calorimetric, or other non-nuclear methods, as well as any other novel methods with potential MC&A benefits.

FC-3.2: Analysis Tools

Methods for data integration and analysis include cutting-edge work in multi-variant statistical techniques for process monitoring, risk assessment, plant-wide modeling & simulation directed at the accounting challenges of high-interest fuel cycle processes, including advanced separations processes.

Used Nuclear Fuel Disposition (FC-4)

(Federal POC – Syed Bokhari & Technical POC – Peter Swift)

This program element develops technologies for storing, transporting, and disposing of used nuclear fuel and high-level radioactive waste and assessing performance of the used fuel and waste forms in the associated storage and disposal environments.

FC-4.1: Storage

Following the issuance of the Blue Ribbon Commission on America's Nuclear Future Final Report in January 2012, interim storage of spent nuclear fuel from reactor sites has gained additional importance and urgency for resolving waste-management-related technical issues. It also provides an opportunity for the scientific community to bring forward new conceptual designs and innovative research in this area. Key university research needs for the storage activities include:

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- Innovative approaches to evaluating degradation and aging phenomena of used nuclear fuel, containers and internals, and storage facilities under extended storage;
- Data and risk informed assessment methods for high-burnup used nuclear fuel for extended storage applications;
- Development of a superior concrete by chemical additives and curing improvements to increase the compressive strength, tensile strength and weather ability of the concrete. This work would not include the addition of mechanical additives such as fiberglass or metal wire. This concrete could then be used for extended used nuclear fuel storage;
- Development of non-destructive techniques to monitor long-term effects of wet/dry, freeze/thaw, marine environment effects, the temperature fluctuations and radiation effects on reinforcing steel and concrete used in the over pack of dry storage system; and
- Innovative research in developing poison materials for long-term criticality control.

FC-4.2: Transportation

Technical issues related to transportation of used nuclear fuel has been generally addressed by past industry studies. However, issues related to transportation of used nuclear fuel after prolonged storage periods provide new challenges. Key university research needs for transportation activities include:

- Materials research that would facilitate transportation of used nuclear fuel;
- Structural integrity assessment for transporting used nuclear fuel with uncertainty in input considerations;
- Advanced modeling approaches for radiological analyses of disruptive scenarios relevant to transportation; and
- Data relevant to risk-informed cask qualification and transportation behavior of high-burnup and advanced fuels.

FC-4.3: Disposal

Assessments of nuclear waste disposal options start with the degradation of waste forms and consequent mobilization of radionuclides, reactive transport through the near field environment (waste package and engineered barriers), and transport into and through the geosphere. Research needs support the development of modeling tools or data relevant to permanent disposal of used nuclear fuel and high-level radioactive waste in a variety of generic disposal concepts, including mined repositories in clay/shale, salt, and crystalline rock, and deep boreholes in crystalline rocks. Key university research needs for the disposal portion of this activity include:

- Improved understanding of degradation processes (i.e., corrosion and leaching) for used nuclear fuel and waste forms that could be generated in advanced nuclear fuel cycles (i.e., glass, ceramic, metallic) through experimental investigations under variable conditions of saturation, temperature, and water chemistry, leading to the development of improved models to represent these processes;
- Improved understanding of the degradation processes for engineered barrier materials (i.e., waste containers/packages, buffers, seals) and radionuclide transport processes through these materials leading to the development of improved models to represent these processes;
- Improved understanding of coupled thermal-mechanical-hydrologic-chemical processes in the near-field of relevant disposal model environments, leading to the development of improved models to represent these processes;
- Improved understanding of large-scale hydrologic and radionuclide transport processes in the geosphere of relevant disposal model environments, leading to the development of improved models to represent these processes;
- Development of new techniques for in-situ field characterization of hydrologic, mechanical, and chemical properties of host media and groundwater in a borehole or an excavated tunnel;
- Aqueous speciation and surface sorption at elevated temperatures and geochemical conditions (e.g., high ionic strength) relevant to the disposal environments being considered;
- Consideration of how specific waste forms may perform in different disposal environments using

theoretical approaches, models, and/or experiments, with quantitative evaluations including uncertainties of how the long-term performance of waste forms can be matched to different geologic media and disposal concepts.
- Experimental and modeling investigations for the effect of radiolysis on used fuel, high-level waste, and barrier material degradation at temperatures and geochemical conditions relevant to potential storage and disposal environments.

FUEL CYCLE OPTION ANALYSIS (FC-5)

(FEDERAL POC – KENNETH KELLAR & TECHNICAL POC – TEMI TAIWO)

This program element performs analysis and evaluates integrated fuel cycle systems with the purpose of identifying and exploring sustainable nuclear fuel cycles that are candidates for future deployment. Results of these studies and R&D activities must be effectively disseminated to program stakeholders and the public in an accurate, open, and simple manner. Proposals are being solicited in the following areas:

FC-5.1: Fuel Cycle Options Catalogue
A catalog of fuel cycle options is currently being developed within the Fuel Cycle Technologies Program. This sub-element is soliciting fuel cycle analysis from universities for the purposes of populating the fuel cycle catalog, developing university expertise in the analysis of advanced fuel cycle systems, and training the next generation of fuel cycle analysts. A draft Fuel Cycle Data Package template that defines the information needed and associated analysis assumptions can be found at www.neup.gov. Proposals to develop Fuel Cycle Data Packages for fuel cycles in any or all of the following fuel cycle groups will be considered for awards:
- *Multi-stage* fuel cycle options using *only* thermal reactors, with the attribute for significantly reducing actinide content of nuclear waste.
- *Multi-stage* fuel cycle designed for continuous recycle of actinides using *only* fast reactors.
- Fuel cycles using targets containing transuranic elements and/or fission products for reducing their content in nuclear waste.

FC-5.2: Fuel Cycle Simulator
It is important to develop effective methods to communicate the potential benefits of alternative nuclear fuel cycle options and associated enabling technologies that could be developed in the future. A significant activity to achieve this is the development of an open-source fuel cycle simulator that will enhance the program's ability to educate, communicate, and support decision-making about future fuel cycles and related technologies. Key university research needs for this activity include:
- Develop modules for the fuel cycle simulator that support specific types of fuel cycles or fuel cycle technologies;
- Develop capabilities for whole system optimization and economic analyses;
- Assistance in building libraries of historic facility/infrastructure information (national/global)

Project Proposals can be for portions or all of the items above. For information about the Fuel Cycle Simulator see http://cyclus.github.com/.

NANONUCLEAR R&D (FC-6)

(FEDERAL POC – INGRID MILTON & TECHNICAL POC – STU MALOY)

The Fuel Cycle Technologies program is initiating a new research topic with the purpose of exploring the potential for nano-science and nano-technologies to support the development of sustainable nuclear fuel cycles. Proposals are being solicited that would make a significant contribution in the area of nanonuclear technology and would result in the development of new capabilities that could be useful to nuclear energy.

This program element investigates the use of nano-particles, nano-structured materials, and/or nano-scale materials, properties, or processes to enhance mechanical, chemical, physical, or thermo-hydraulic properties and performance in nuclear fuel cycle applications, such as:

Program Supporting: Fuel Cycle Technologies

- Reactor (in-core) materials with nano-scale precipitates that could improve mechanical performance as well as radiation tolerance.
- Nano-scale coatings that could be included on the exterior or the interior of fuel cladding to improve corrosion resistance and surface hardening, and pellet-clad interactions on the cladding interior.
- Chemical interaction and separation methods using nano-particles and/or nano-porous materials that can enable techniques to capture fission product gases either from reprocessing operations or directly within a reactor fuel assembly thereby reducing the potential for releases from normal or accident conditions.
- Advanced fuels engineered and/or fabricated with nano-technologies to enable longer service lives, reduce fabrication process losses, and/or reduce the potential for failure in normal or accident conditions including increased fission gas retention, plasticity, radiation tolerance, heat transfer capability, as well as reduced fuel cladding chemical and/or mechanical interactions.
- Nano-technology enabled sensors and/or in-service monitors that can directly monitor for radiation, temperature, pressure, in situ diagnostics of material properties and mechanical response, corrosion, neutron flux, stress/strain or even chemistry with little effect on system performance with significantly reduced size and weight and increased sensitivity, performance, and functionality.
- Nanotechnology-based detectors that can discriminate between neutron and gamma radiation and/or have enhanced sensitivity for the detection of fissile materials with very low neutron activation fluxes.

Proposals are sought from research teams, with a demonstrated connection to basic nano-science research.

Mission Supporting: Fuel Cycle Technologies

Fuel Resources (MS-FC1)

(Federal POC – Stephen Kung & Technical POC – Sheng Dai)

The secure and economical supply of nuclear fuel is essential for the long-term use of nuclear power for energy applications. Continued federal R&D investment in uranium resources will be the foundation to enable future nuclear power expansion. The focus of fuel resources R&D is to identify “game-changing” approaches not presently being addressed by private industry or non-governmental organizations. Specific areas of interest include: (1) molecular-level understanding of the coordination modes, sorption mechanisms, and kinetics of uranium extraction; (2) design and synthesis of functional ligands with architectures tailored chemical performance; (3) physical and chemical tools for characterizing of adsorbent materials; (4) development of new polymer sorbents via advanced manufacturing and surface grafting techniques; and (5) development of innovative elution processes.

Nuclear Data and Measurement Techniques (MS-FC2)

(Federal POC – Daniel Vega & Technical POC – Tony Hill)

This research topic will pursue advanced measurement techniques that could complement the ongoing measurement program. Such a topic includes Innovative ideas for detector development and testing to collect high fidelity data for improvements in cross section evaluations, covariance data, multiplicity, and spectrum information for candidate fuel and structural materials. In addition, robust sensitivity analyses are required to prioritize high value data collection and refinement techniques.

Program Supporting: Nuclear Reactor Technologies

COMPUTATIONAL METHODOLOGIES (RC-1)

(FEDERAL POC – STEVE REEVES & TECHNICAL POC – HANS GOUGAR)

Computational methodologies R&D is focused on providing practical tools to analyze the gas-cooled reactor core neutronics/thermal-hydraulics, performance; reactor gas-coolant thermal fluids behavior during normal and transient conditions, and accident scenarios; and safety evaluations for advanced gas reactor reactors and design of scaled experiments. Additionally, the computational fluid dynamics code validation, verification, uncertainty, and qualification benchmark effort is focused on validating practical tools to analyze advanced gas reactor passive cooling systems.

Research efforts have been initiated and/or completed in the areas of neutronics, thermal-hydraulics, and multiphysics, in terms of time-dependent coupled fuel/neutronics/thermal fluids modeling, reactor kinetics effects, and mechanical-neutronics-thermal fluid interactions during graphite dimensional changes under irradiation with thermal and neutronics feedback. Advanced reactor plant simulation and safety analysis methods development has been initiated for uncertainty and sensitivity analysis for statistical importance ranking. Integral effects experiments focused on in-vessel thermal fluids are underway at the High Temperature Test Facility (Oregon State University) and complementary separate and mixed effects experiments have been planned and initiated. Similarly, an ex-vessel integral test is being constructed at Argonne National Laboratory (Natural Circulation Shutdown Test Facility) with complementary experiments underway at some universities to generate data on ex-core heat removal and cavity cooling. A range of supporting scaled fundamental, separate, and mixed effects experiments are needed to complement these integral tests.

Thermal-hydraulics methods proposals are sought in the areas of:

- Steam ingress flow and chemistry particularly among lower support structures,
- Plenum-to-plenum heat transfer under natural circulation,
- Experimentally-validated analyses of heated two-component stratified or bypass flow,
- Methods that integrate externally initiated events (e.g. earthquake, flooding) and core/reactor dynamics and structures vibrations (e.g. graphite reflector and prismatic block movement)
- Validation of models using safety analysis and CFD codes (e.g. RELAP5, TRAC, STAR-CCM+, and FLUENT but other NRC or reactor vendor computer simulation codes will also be considered).

ADVANCED TECHNOLOGIES, DEVELOPMENT AND DEMONSTRATION (RC-2)

(FEDERAL POC – BRIAN ROBINSON & TECHNICAL POC – BOB HILL)

Advanced technologies can enable new Small Modular Reactor (SMR) concepts and designs to achieve even greater levels of safety and resilience, flexibility of use, sustainability and construction or operational affordability. SMRs differ from large plants in their fundamental design features, which may require or benefit from new analysis methods to quantitatively characterize the performance and risk factors associated with SMRs. Innovative engineering techniques for operations and reliability are sought that are designed from the outset to provide increased levels of safety and robustness and new functionalities while also maintaining or improving the performance. These advanced technologies or innovative engineering techniques have to lead to economically viable concepts for eventual commercial deployment. We are seeking proposals that support the identified needs of our advanced reactor technology development efforts specifically in the following areas:

RC-2.1: INSTRUMENTATION, CONTROL, HUMAN, MACHINE INTERFACE (ICHMI) (E.G. ADVANCED HIGH TEMPERATURE INSTRUMENTATION, IN-SERVICE INSPECTION TECHNIQUES OR DIAGNOSTIC AND PROGNOSTIC SYSTEMS).

RC-2.2: COMPONENT AND TECHNOLOGY DEVELOPMENT (E.G. CORROSION AND OXYGEN CONTROL SYSTEMS OR COMPACT HEAT EXCHANGER DESIGNS).

Program Supporting: Nuclear Reactor Technologies

ADVANCED STRUCTURAL MATERIALS (RC-3)

(FEDERAL POC – BILL CORWIN & TECHNICAL POC – JEREMY BUSBY)

Specific areas of materials technology supporting the development of advanced reactor systems are recognized to need additional research and are the focus of requests for proposals this year. The two areas in which work is being solicited are: 1) the long-term prediction of emissivity of structural materials for high temperature reactor systems and 2) the experimental measurement and prediction of creep-fatigue in applicable high-temperature alloy systems.

RC-3.1: LONG-TERM EMISSIVITY

The passive cooling of some high temperature reactor systems depends upon decay heat transfer through the reactor pressure vessel (RPV) wall and its radiative dissipation into the reactor cavity. This process requires an adequately high emissivity on the outer surface of the RPV, as well as any inner surfaces in the vessel interior and internals integrally involved in radiative heat transfer. Building upon existing short-term studies of vessel emissivity, develop and validate models of emissivity of the relevant RPV and internals materials for up to 60 years of operation to predict lifetime emissivity values of pressure vessel and reactor internal materials in air and/or relevant reactor coolants.

RC-3.2: CREEP FATIGUE

Accurate predictions of the interactions of creep and fatigue for structural materials for advanced, high-temperature reactors are critical for safety and design, but are limited by the limitations of the available experimental data upon which such models and predictions are based. Most experimental data developed for creep-fatigue interactions are fundamentally fatigue tests with various types of tensile or compressive hold periods superimposed on them. The resulting data typically includes more fatigue damage than creep damage, whereas in many high temperature nuclear components in long-term service the actual mix of damage often includes more creep than fatigue. Hence, proposals are sought to generate a better mechanistic understanding of creep-fatigue interactions, especially under loading conditions where creep is the predominant damage mechanism. Materials of interest include Alloy 617, Alloy 800H, 9Cr-1MoV and other alloys for advanced high temperature reactor application. Approaches might include novel experimental methods and/or modeling with substantial experimental validation.

MATERIALS AGING AND DEGRADATION: ACCELERATED TEST TECHNIQUES AND VALIDATION (RC-4)

(FEDERAL POC – RICHARD REISTER & TECHNICAL POC – JEREMY BUSBY)

Materials and components under extended service conditions will see very long lifetimes under stress, temperature, corrosive coolant, and/or neutron or gamma radiation fields. Clearly, it is not viable to start laboratory tests at this time to duplicate 80 years of life in a timely manner. Some accelerated testing will be necessary. Techniques and approaches for providing relevant data using accelerated test techniques are sought. Modeling tools, experimental studies, and/or validation of accelerated testing and material response are appropriate for key reactor materials under relevant environments including, but not limited to stress, corrosive environment, radiation, and elevated temperature. Interpretation via modeling and simulation of material aging response using non-destructive evaluation techniques is of particular interest. Materials of interest include, but are not limited to, core internal components (stainless steels), cast stainless steel piping, reactor pressure vessel steels, concrete, and cable insulation. Universities engaging in this effort will be expected to produce concepts, supporting data and/or model predictions demonstrating the viability of these techniques with a high level of quality assurance.

Program Supporting: Nuclear Reactor Technologies

Risk-Informed Safety Margin Characterization (RISMC): Advanced Mechanistic 3D Spatial Modeling and Analysis Methods to Accurately Represent Nuclear Facility External Event Scenarios (RC-5)

(Federal POC – Richard Reister & Technical POC – Curtis Smith)

A current gap in safety modeling for nuclear facilities is robust external events modeling such as spatial impacts and interactions from seismic events. Consequently, modeling complex spatial phenomena at current and future nuclear power plants related to external environmental impacts will be important for predictive performance and safety evaluations. To capture both normal and off-normal conditions, the plant behavior and response will seek to allow for mechanistic scenario representations, wherein the developed methods mimic the complicated behavior. Universities helping in this activity will be expected to provide mechanistic approaches that represent spatial types of interactions through a physics-based 3D environment. These environments should be capable of mimicking realistic physics such as water through building flow paths; failures of components and structures; and objects impacting other objects in order to represent probabilistic external events. These methods should be compatible with the INL-developed MOOSE (Multiphysics Object Oriented Simulation Environment) platform that is the platform used in other modeling activities in the LWRS program. It is the goal of the research and development to couple probabilistic and mechanistic calculations together such that we will be able to search for potential vulnerabilities resulting from external events.

Instrumentation, Information, and Control: Monitoring Technologies for Severe Accident Conditions (RC-6)

(Federal POC - Damian Peko & Technical POC - Dwight Clayton)

The accidents at the Three Mile Island Unit 2 (TMI-2) and Fukushima Daiichi Units 1, 2, and 3 nuclear power plants demonstrate how monitoring instrumentation can be important to managing severe accidents but that the harsh environments of severe accident challenge those instrumentation systems.

With currently design approaches, the environments such instruments would function in during severe accidents could be significantly harsher in terms of high temperatures, high pressures, high radiation fields, high temperature gradients, etc) and designers also need to consider loss of external power sources. Novel technologies, such as remote (stand-off) sensors, wireless technology, and self-powered instruments have emerged since the design of many current NPPs. Application of these novel technologies could fundamentally change the challenges associated with deploying a severe accident monitoring capability. Self-powered instruments relieve designers of the challenge of ensuring an external power supply. Wireless technologies relieve designers of the burden of routing and protecting wires. Standoff monitoring capabilities relieve designers of the burden of having to design and deploy instrumentation to withstand the harsh environment it is trying to measure by removing the instrument to a more benign location.

Research in novel technologies is sought that, by eliminating or simplifying some of the challenges associated with current design approaches, will result in simpler, more economical instrumentation for monitoring an NPP during severe accident conditions than is possible with current instrumentation design approaches. Possible responses to this call would include novel technologies for monitoring water level, temperature and pressure, fuel and component temperature, reactor power level, containment pressure, temperature, and hydrogen concentration.

Program Supporting: Nuclear Reactor Technologies

Radioisotope Power Systems: Innovative Fuel Form Processing Development of General Purpose Heat Sources for NASA Applications (RC-7)

(Federal POC – Alice Caponiti & Technical POC – Stephen Johnson)

Space and Defense Power Systems program has designed, developed, built and delivered radioisotope power systems (RPS) for space exploration and national security applications for over fifty years. Radioisotope power systems uniquely enable missions that require a long-term, unattended source of electrical power and/or heat in harsh and remote environments. These systems are reliable, maintenance free, and capable of producing heat and electricity for decades. These systems convert the decay heat from Pu-238 into electricity – either using thermoelectric couples to induce direct current electricity flow in the case of radioisotope thermoelectric generators or through a dynamic energy conversion system using free-piston Stirling engines in the case of Stirling radioisotope generators currently under development. Both types of RPS designs use the General Purpose Heat Source – an aero shell module which contains four ceramic fuel pellets clad in iridium and nested in layers of graphitic structures to provide thermal and impact protection. Many of the technologies and materials used in the General Purpose Heat Source were developed decades ago. Proposals for improving current manufacturing processes are encouraged.

Proposals are sought for new and innovative methods of manufacturing ceramic Pu-238 heat sources that are enveloped by the geometry and heat output of current designs and lead to enhanced safety performance. The ceramic product should be compatible with the current iridium alloy used in the encapsulation process. An emphasis on reliable processing parameters and enhanced personnel safety should be considered paramount in a new method of production.

Mission Supporting: Nuclear Reactor Technologies

Reactor Concepts RD&D - (MS-RC1)

(Federal POC – Sal Golub & Technical POC – Bob Hill)

Development of new reactor concepts that may offer the potential for revolutionary improvements to reactor performance and/or safety is sought. Such advanced reactor concepts could include the incorporation of advanced systems or components into existing concepts (e.g. Generation-IV systems such as the gas fast reactor, molten salt reactor or lead fast reactor), inclusion of innovative design alternatives (e.g., new fuel type, nano-engineered coolants, etc.), or designs employing radically different technology options (e.g., advanced coolants, fuel, or operational regimes). Concepts could also include small modular reactors with unique capabilities to address operational missions other than the delivery of baseload electric power, such as industrial process heat or mobile reactors that can provide temporary power during emergency situations. The scope of the proposed project should include a thorough viability assessment of the concept, a detailed technology gap analysis and a comprehensive technology development roadmap that identifies research needed on key feasibility issues.

Radioisotope Power Systems R&D – (MS-RC2)

(Federal POC – Alice Caponiti & Technical POC – Stephen Johnson)

Space and Defense Power Systems program has designed, developed, built and delivered radioisotope power systems (RPS) for space exploration and national security applications for over fifty years. Radioisotope power systems uniquely enable missions that require a long-term, unattended source of electrical power and/or heat in harsh and remote environments. These systems are reliable, maintenance free, and capable of producing heat and electricity for decades. These systems convert the decay heat from Pu-238 into electricity – either using thermoelectric couples to induce direct current electricity flow in the case of radioisotope thermoelectric generators or through a dynamic energy conversion system using free-piston Stirling engines in the case of Stirling radioisotope generators currently under development. Both types of RPS designs use the General Purpose Heat Source – an aero shell module which contains four ceramic fuel pellets clad in iridium and nested in layers of graphitic structures to provide thermal and impact protection. Materials used in the early designs for these systems are increasingly difficult to obtain. Proposals that identify more readily available materials that can perform effectively in the extreme environment of atmospheric re-entry are encouraged.

Proposals are sought for the development of alternate materials for the aero shell module that protects radioisotope power system fuel during potential atmospheric reentry events. The material will need ablation resistance, thermal conductivity, and structural strength (compressive and tensile) that meet minimum performance requirements.

Program Supporting: Science and Technology Innovation

NUCLEAR ENERGY ADVANCED MODELING AND SIMULATION (NEAMS)

VALIDATING NEAMS FUEL PIN MODELS (NEAMS-1)

(FEDERAL POC – DAN FUNK & TECHNICAL POC – KEITH BRADLEY)

The Nuclear Energy Advanced Modeling & Simulation (NEAMS) program is focused on developing improved analytical capabilities for simulating the performance of advanced reactors and fuels. NEAMS is producing a comprehensive “pellet-to-plant” simulation toolkit through efforts within two product lines: Fuels and Reactors. The Fuels Product Line is building tools that incorporate mechanistic material behavior models with modern computational methods and up-to-date computer hardware. The Reactor Product Line supports analysis of advanced reactor performance by providing three dimensional, high-fidelity, coupled-physics simulation capability that scales with the needs of the user and the complexity of the problem. This product line also supports Relap-7 development in conjunction with NE’s Light Water Reactor Sustainability Program to improve upon 30 years of experience with RELAP 5. NEAMS is soliciting contributions as follows:

Performance of validation studies using the NEAMS tools for predicting fuel performance in a Light Water Reactor (LWR) environment. Of particular interest is the assessment of the engineering-scale tool (BISON) against experimental data for Pressurized Water Reactor (PWR) fuel pins contained in the FRAPCON, FRAPTRAN, and FUMEX-III experimental databases. Both deficiencies in irradiation performance models as well as gaps in the experimental databases should be identified as areas needing further development.