U.S. DEPARTMENT OF ENERGY
Defense Nuclear Nonproliferation

Global Threat Reduction Initiative

National Nuclear Security Administration
Defense Nuclear Nonproliferation

GTRI's Mo-99 Program

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GTRI Mission & Program Goals

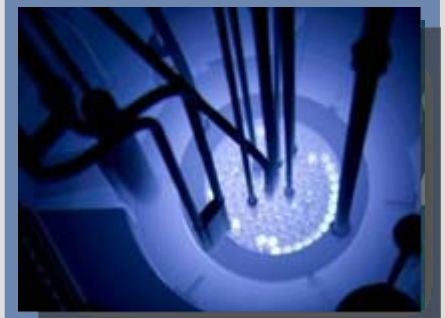
Mission

reduce and protect vulnerable nuclear and radiological material located at civilian sites worldwide.

Goals

1. CONVERT
2. REMOVE
3. PROTECT

Convert



Convert research reactors and isotope production facilities from the use of highly enriched uranium (HEU) to low enriched uranium (LEU)

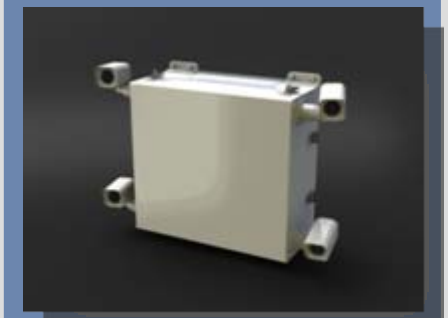
These efforts result in permanent threat reduction by minimizing and, to the extent possible, eliminating the need for HEU in civilian applications – each reactor converted or shut down eliminates a source of bomb material.

Remove

Remove and dispose of excess nuclear and radiological materials.

These efforts result in permanent threat reduction by eliminating bomb material at civilian sites – each kilogram or curie of this dangerous material that is removed reduces the risk of a terrorist bomb.

Protect



Protect high priority nuclear and radiological materials from theft and sabotage

These efforts result in threat reduction by improving security on the bomb material remaining at civilian sites – each vulnerable building that is protected reduces the risk until a permanent threat reduction solution can be implemented.

GTRI's Mo-99 Projects
Objective and Strategy

Objective: Accelerate the establishment of a reliable supply of the medical isotope molybdenum-99 produced without highly enriched uranium.

GTRI's strategy seeks to address weaknesses in the current Mo-99 supply chain.

The current supply chain uses HEU to produce Mo-99.
- Support the conversion of Mo-99 production from HEU targets to LEU targets.
- Supply availability of HEU for the fabrication of Mo-99 production targets is a risk.
- Any potential producer in the United States must utilize non-HEU-based technology.

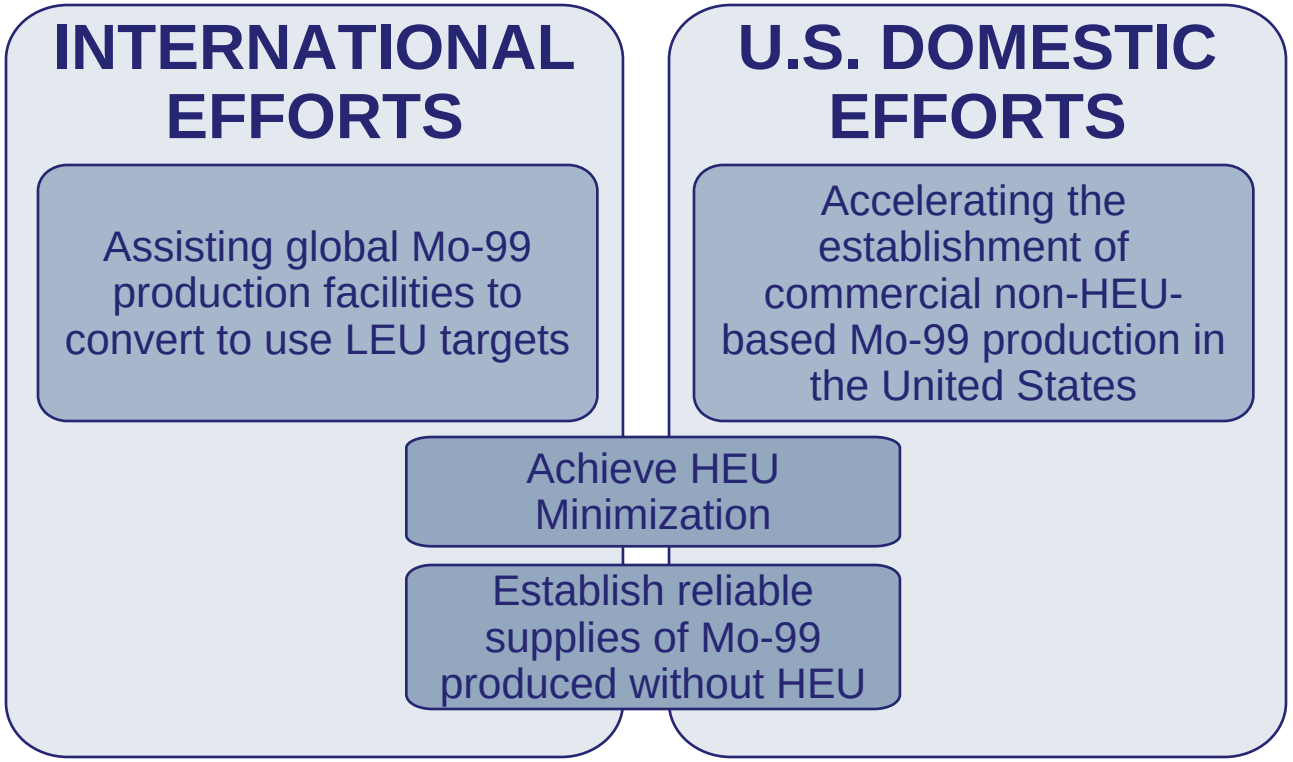
The current supply chain does not have enough reserve capacity to ensure a reliable supply when a producer is out of operation.
- GTRI is supporting four separate commercial entities to accelerate commercial production in the United States.
- GTRI's objective is for each project to develop the capacity to produce approximately half the U.S. demand if needed. Market forces will determine actual levels of production, however the capacity to produce at least half the U.S. demand allows enough reserve capacity should other producer(s) be out of operation.

The current supply chain relies on one technology to produce Mo-99.
- GTRI's strategy is to avoid a single point of failure by supporting the development of a diverse set of non-HEU-based technologies to reduce the risk of depending on one Mo-99 production technology.

The current supply chain is dependent on aging facilities.
- GTRI is supporting investment in new infrastructure in the United States.

GTRI & Mo-99
International & U.S. Domestic Approaches

- Under its long-standing HEU minimization mission, GTRI provides assistance to research reactors and isotope production facilities to convert from the use of HEU to LEU.
- GTRI's mission includes accelerating the establishment of a reliable U.S. domestic supply of Mo-99 produced without the use of HEU.



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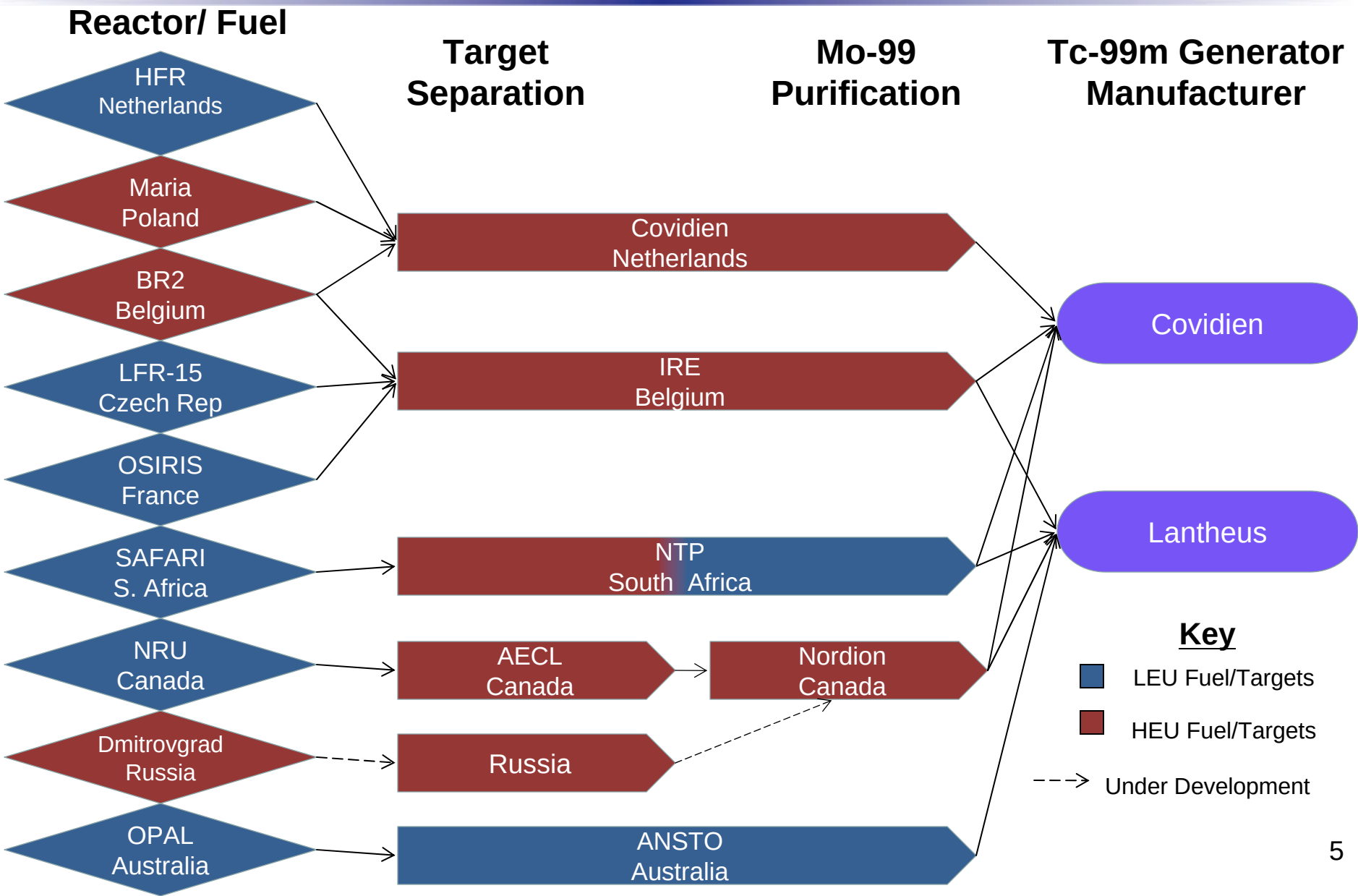
Current U.S. Mo-99 Supply Matrix

With New & Expanded Sources since 2010



GTRI & Mo-99

Strategy for Reliable Non-HEU-Based Mo-99 Supply

Global Mo-99 Market – Major Producers

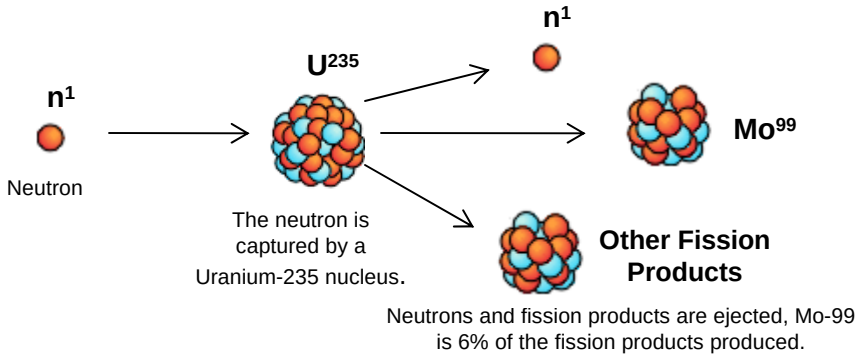
HEU | Non-HEU

NTP Radioisotopes (South Africa)	ANSTO (Australia)	Covidien (Netherlands)	IRE (Belgium)	AECL-Nordion (Canada)
NTP Radioisotopes (South Africa)	ANSTO (Australia)	Covidien (Netherlands)	IRE (Belgium)	AECL-Nordion (Canada)
NTP Radioisotopes (South Africa)	ANSTO (Australia)	Covidien (Netherlands)	IRE (Belgium)	

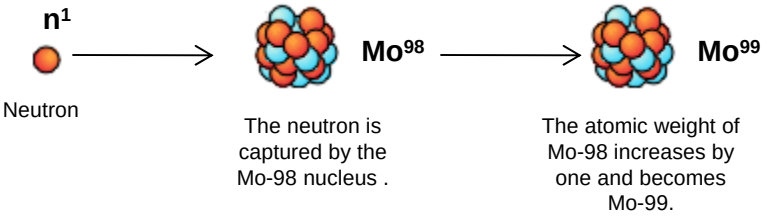
U.S. Domestic Mo-99 Projects

GTRI and U.S. Domestic Mo-99:
Non-HEU Production Methods

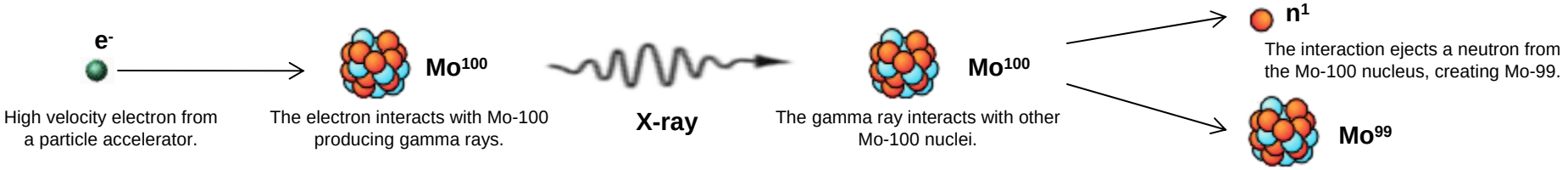
LEU Fission Based: $U^{235}(n,f)$



Neutron Capture: (n,γ)



Accelerator Based: (γ,n)

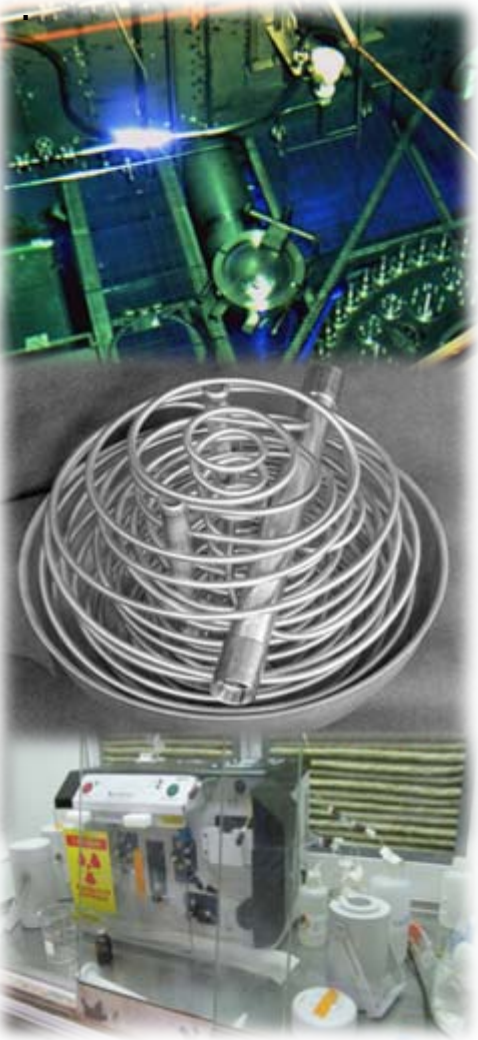


Supporting Commercial Production of Mo-99 in the United States

- GTRI has established partnerships with four U.S. commercial entities to pursue the establishment of independent non-HEU-based technology pathways.
- In 2009, NNSA entered into cooperative agreements with two commercial partners.
- In 2010, NNSA issued a Funding Opportunity Announcement (FOA) to select two additional cooperative agreement partners. The FOA was issued on March 24, 2010 and closed June 11, 2010 and was implemented under 10 CFR 600 Subpart H, Assistance Regulations.
- Each application received under the FOA was evaluated first for technical merit and then business-case viability.
- As part of the assessment process, an independent technical review team evaluates progress of the individual projects on a semi-annual basis.

GTRI and U.S. Domestic Mo-99:
Cooperative Agreement Partners

Objective: To accelerate existing commercial projects to meet at least 100% of the U.S. demand of Mo-99 produced without HEU.



Neutron Capture:

- On September 30, 2009, NNSA awarded a cooperative agreement to General Electric-Hitachi for $2.3M to pursue neutron capture technology.

LEU Solution Reactor Technology:

- On September 30, 2009, NNSA awarded a cooperative agreement to Babcock and Wilcox (B&W) for $9.1M to pursue the LEU solution reactor technology.

Accelerator Technology:

- On September 29, 2010, NNSA awarded a limited-scope cooperative agreement to NorthStar Medical Radioisotopes, LLC for $500,000 to pursue accelerator technology. On September 19, 2011, NNSA awarded an additional cooperative agreement for $2.3M.

- On September 29, 2010, NNSA awarded a limited-scope cooperative agreement to Morgridge Institute for Research for $500,000 to pursue accelerator technology. A proposal for an additional cooperative agreement is currently under evaluation.

Each cooperative agreement project is limited to $25M, under a 50% - 50% cost-share arrangement.

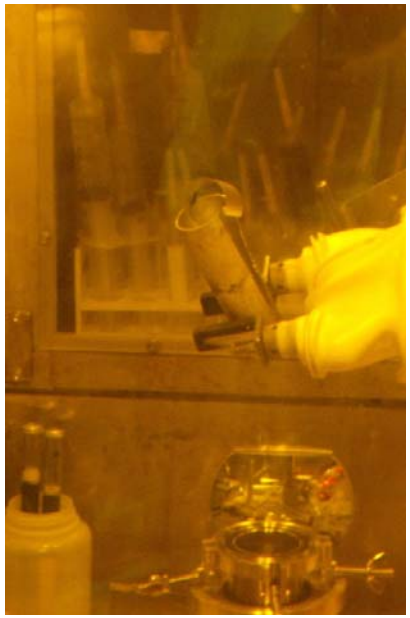
U.S. National Laboratories Support to Mo-99 Production

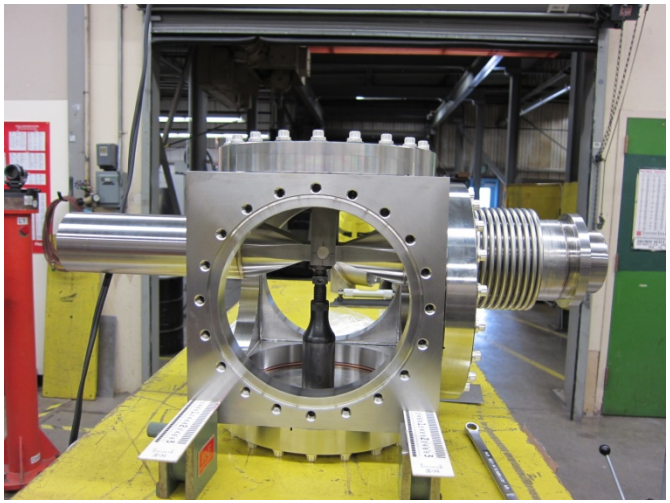
GTRI makes the expertise of the U.S. National Laboratories available to:

- Support technical development of each of the Mo-99 technical pathways
- Ensure the expertise at the national laboratories is available to support the acceleration of commercial projects using non-HEU technologies

All work packages funded by NNSA outside the cooperative agreement are open-sourced, non-proprietary, non-critical-path activities.

All labs working on the Mo-99 projects will be representing their work at this Mo-99 Topical Meeting.





Meeting NEPA Obligations

Each of GTRI's domestic Mo-99 projects must be compliant with the National Environmental Policy Act (NEPA). NEPA requires federal agencies to consider the environmental consequences of proposed actions before significant funding decisions are implemented.

To comply with NEPA requirements, the NNSA follows the Council on Environmental Quality regulations (40 CFR 1500-1508) and the DOE implementing regulations (10 CFR 1021).

GTRI provides support to the cooperative agreement partners in two phases in accordance with NEPA obligations:

- **Phase 1:** GTRI supports activities that are "categorically excluded" from NEPA, or already covered under an existing NEPA document.
  - e.g. conceptual and preliminary design, project management, engaging with regulator, etc.

- **Phase 2:** Once GTRI's NEPA obligations are fulfilled, GTRI expects to be able to fully fund the cooperative agreement partner for all activities, up to a total funding limit of $25M.

Currently, all of GTRI's domestic cooperative agreement partnerships are in

Coordinating A Reliable Mo-99 Supply

Stakeholder Involvement

- **Office of Science and Technology Policy (OSTP)**
  - Interagency Working Group (est. 2009)
  - Stakeholder Outreach (est. 2009)

- **Organization for Economic Cooperation and Development – Nuclear Energy Agency**
- High Level Group on the Security of Supply of Medical Radioisotopes (HLG-MR) (est. 2009)

- **International Atomic Energy Agency (IAEA)**
  - Conversion Planning for Mo-99 Production from HEU to LEU (est. 2009)
  - Small-Scale Indigenous Production Using LEU Targets or Neutron Activation (est. 2005)
  - Current and Novel, Non-HEU-Based Isotope Production and Supply Technologies for Mo-99 and Tc-99m (est. 2009)
  - Feasibility Evaluation of the Use of Low Enriched Uranium Fuelled Homogeneous Aqueous Solution Nuclear Reactors for the Production of Short Lived Fission Product Isotopes (GTRI is an observer only)
  - Progress with the Production of Molybdenum-99 using Neutron Activation (GTRI is an observer only)

- **Community Outreach**