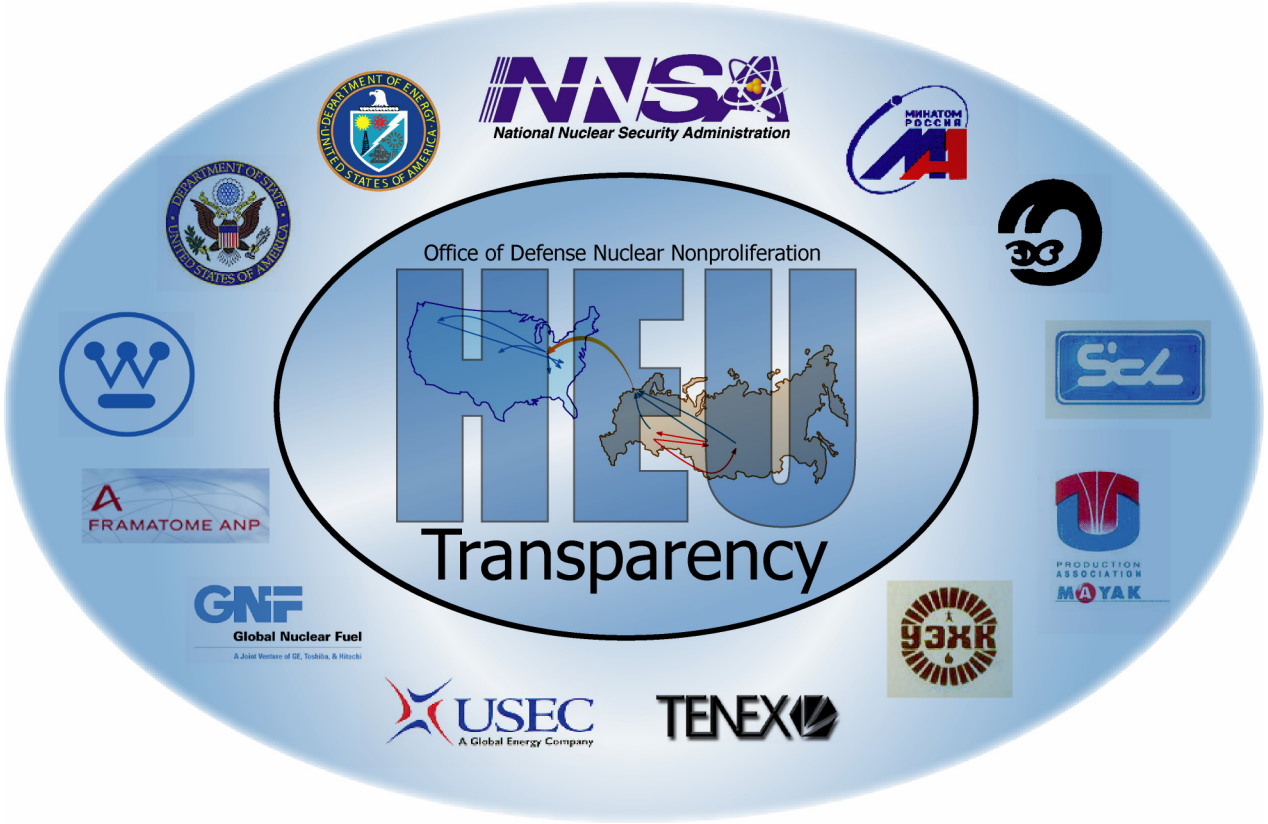
Highly Enriched Uranium Transparency Program



Office of Dismantlement and Transparency

The United States-Russian Intergovernmental HEU-LEU Agreement

In 1993 the United States agreed to purchase 500 metric tons of HEU from dismantled Russian nuclear weapons, in the form of 15,000 metric tons of LEU, for approximately $12 billion over 20 years.

"Megatons" are being converted to……

…….."Megawatts" under the U.S.-Russian Intergovernmental HEU-LEU Agreement

This Agreement provides LEU for fabrication into power reactor fuel, with equivalent energy to meet all U.S. electricity demand for two years. The Agreement's transparency measures assure that the nonproliferation objectives of this Agreement are met, including provisions for nuclear material accounting and control.

Evolution of the HEU-LEU Agreement

August 31, 1992: President Bush (pictured with President Yeltsin) announced that the United States and the Russian Federation have negotiated and initialed the HEU Purchase Agreement

March 18, 1994: Vice-President Gore and Russian Prime Minister Chernomyrdin sign Protocol on HEU Transparency Arrangements in Washington, D.C.

June 30, 1995: Energy Secretary O'Leary and Russian Minister Mikhailov sign Joint Statement on Transparency Arrangements in Moscow

Transparency Overview

- Transparency is those agreed upon measures used to build confidence that the arms control and nonproliferation objectives of the 1993 United States - Russian Highly Enriched Uranium (HEU) Agreement are being met.

- The goal of the HEU Transparency Program (TP) is to support United States (U.S.) nonproliferation policy by providing confidence that Russian low enriched uranium (LEU) sold to the United States is derived from HEU removed from dismantled Russian nuclear weapons.

- The Program benefits United States nonproliferation policy by assuring the permanent removal of 500 metric tons of weapons-grade HEU in Russia, equivalent to about 20,000 nuclear weapons.

Highly Enriched Uranium Transparency Program

- **Transparency measures are to assure that:**

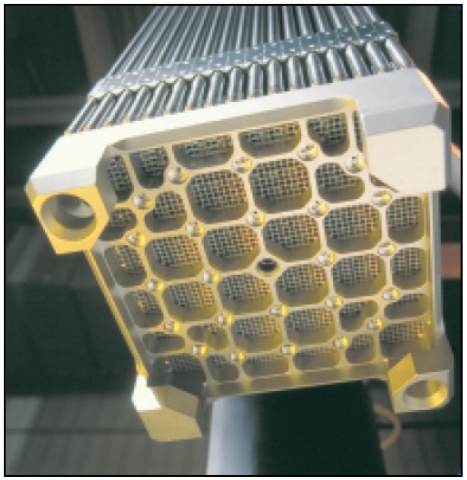
HEU is from Russian weapons-usable material.

Tactical nuclear device being loaded

This same HEU is converted and downblended to LEU.

HEU-TP monitor at a Russian facility glove box that is used to burn uranium metal and produce uranium oxide

The LEU shipped to the United States is fabricated into fuel for commercial nuclear reactors.

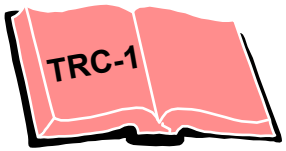


Nuclear fuel rod assembly

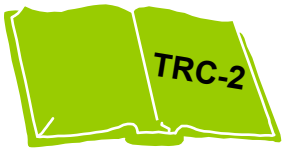
- **We have full access to four Russian plants per the Agreement.**
- **Accomplished over ten years of transparency monitoring activity.**
- **Provide support to US nonproliferation policy initiatives.**

Transparency Chronology

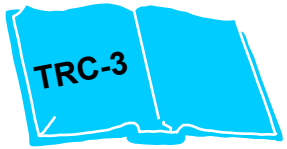
- The United States held the first HEU transparency discussions with Russia in March 1993.
- In May 1993, a U.S. delegation conducted the first visit to a Russian processing facility where HEU will be blended down into LEU.
- In June 1993, a Russian delegation conducted its first visit to the Portsmouth, Ohio Enrichment Plant and to a U.S. fuel fabricator.
- Memorandum of Understanding (MOU) related to Transparency signed in September 1993.
- Protocol to the MOU signed in March 1994. It provides additional details on transparency rights and establishes the U.S./Russian Transparency Review Committee (TRC).
- The second TRC signs Annexes 1 & 2. Each annex provides specific detail on implementing monitoring rights for each country.
- On June 23, 1995, the first shipment of LEU converted from weapons HEU arrives at the Portsmouth, Ohio enrichment plant.



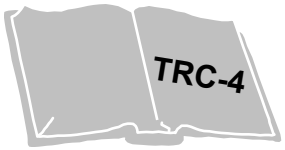
September 1994



July 1995

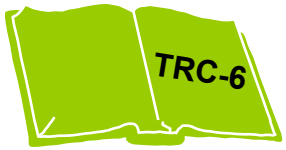


November 1995



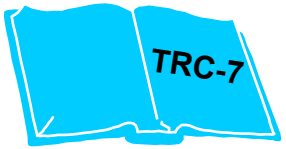
April 1996

December 1996



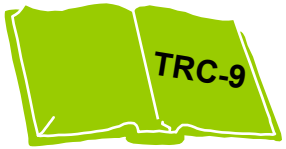
November 1997

February 1998



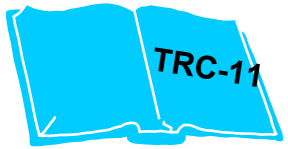
July 1999

July 2001



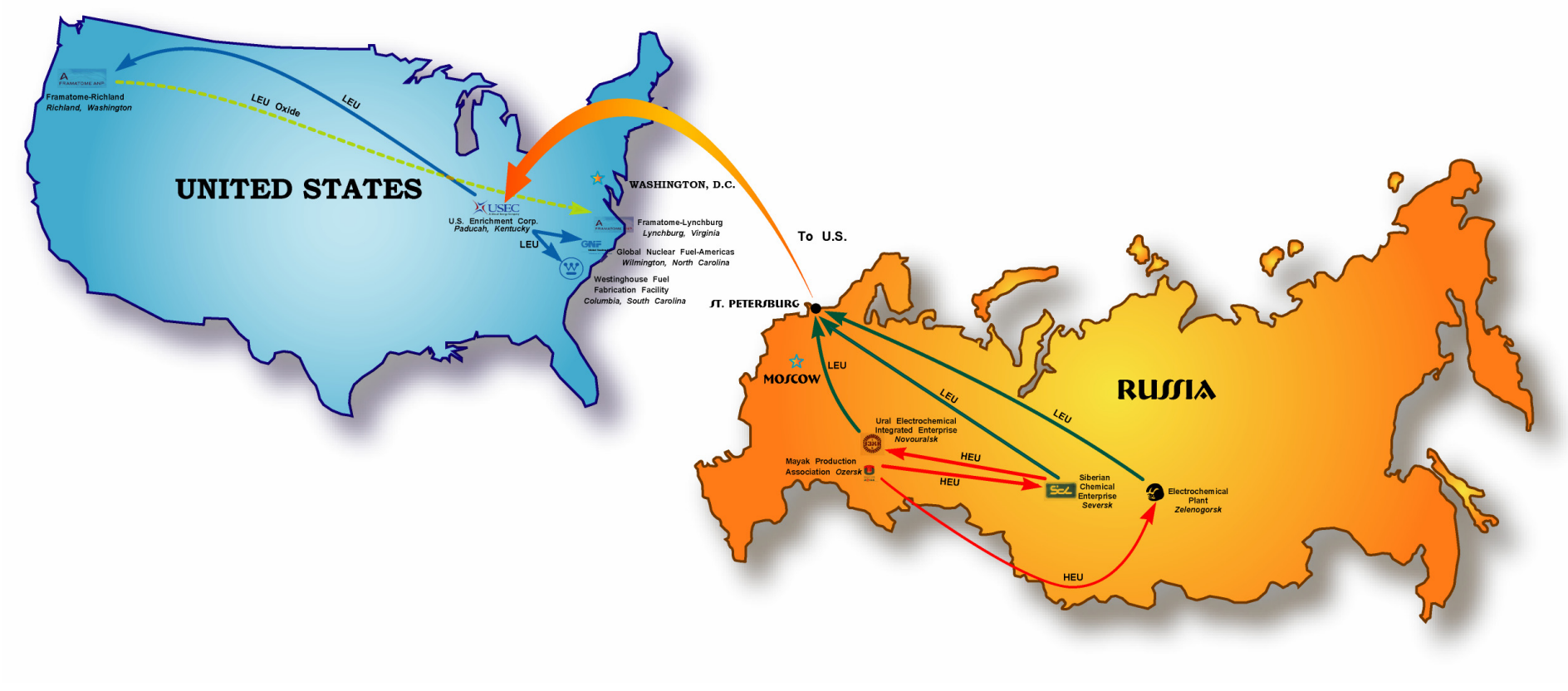
November 2002

August 2003



April 2004

Facilities Subject to the Agreement



Arrows Indicate the Flow of Material

Red is HEU ***Gold / Blue is LEU***

Russian Facilities and Processes

Two Russian facilities receive HEU weapons components from dismantled Russian nuclear weapons

Siberian Chemical Enterprise (SChE) in Seversk

HEU-TP monitors inspect weapons component transport containers at MPA

- Receive weapons components
- Convert metal components to chips
- Convert metal chips to oxide
- Purify the oxide
- Ship purified oxide to SChE & ECP

HEU-TP monitors inspect HEU oxide containers at SChE

Mayak Production Association (MPA) in Ozersk

Russian Facilities and Processes

Three Russian facilities convert and blend down HEU to LEU for shipment to the United States

Blend point at SChE

Siberian Chemical Enterprise

LEU cylinder filling station at ECP

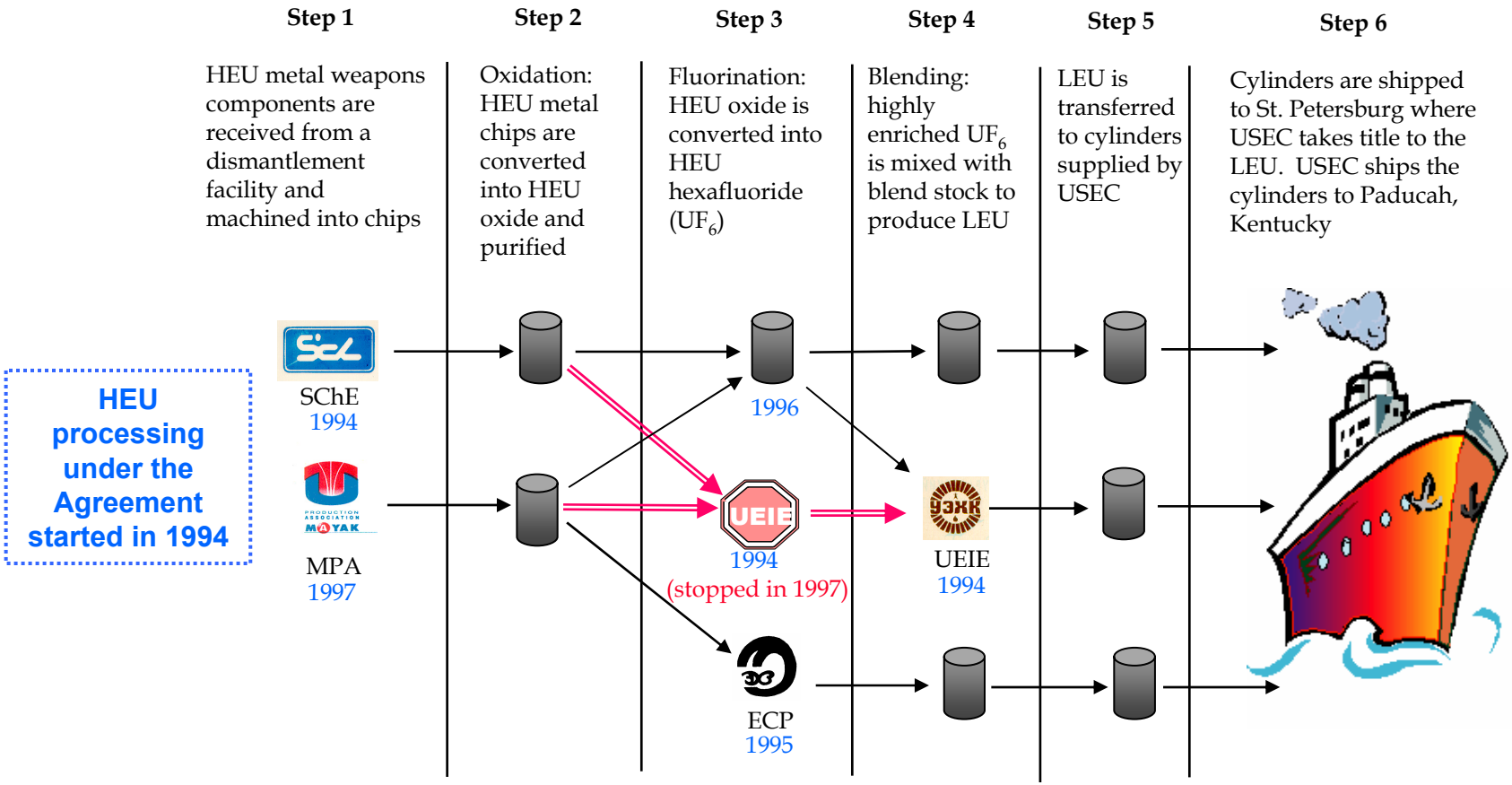
Electrochemical Plant (ECP) in Zelenogorsk

- Receive HEU oxide
- Convert oxide to UF_6
- Down blend HEU into LEU
- Ship LEU to USEC

Ural Electrochemical Integrated Enterprise (UEIE) in Novouralsk

Uranium hexafluoride transfer station at UEIE

Transparency Program: Monitoring the Conversion of HEU Weapons Components to LEU



Double lines indicate discontinued activities. Stop sign at UEIE indicates fluorination operations ceased in 1997.

USEC - United States Enrichment Corporation
MPA - Mayak Production Association, Ozersk
UEIE - Ural Electrochemical Integrated Enterprise, Novouralsk
ECP - Electrochemical Plant, Zelenogorsk
SChE - Siberian Chemical Enterprise, Seversk

Process Facilities in the United States

Russian monitors at the Paducah Gaseous Diffusion Plant observe NDA test on LEU cylinder from Russia

Paducah Gaseous Diffusion Plant receives all LEU shipped from Russia.

Last Russian Monitoring visit to the United States was in October 2005.

Five U.S. fuel fabricators subject to monitoring by Russian Federation:

- *Global Nuclear Fuel-Americas, Wilmington, NC*
- *Framatome-Lynchburg, Lynchburg, VA*
- *Framatome-Richland, Richland, WA*
- *Westinghouse Nuclear Fuel, Columbia, SC*
- *Westinghouse-Hematite*, Hematite, MO*

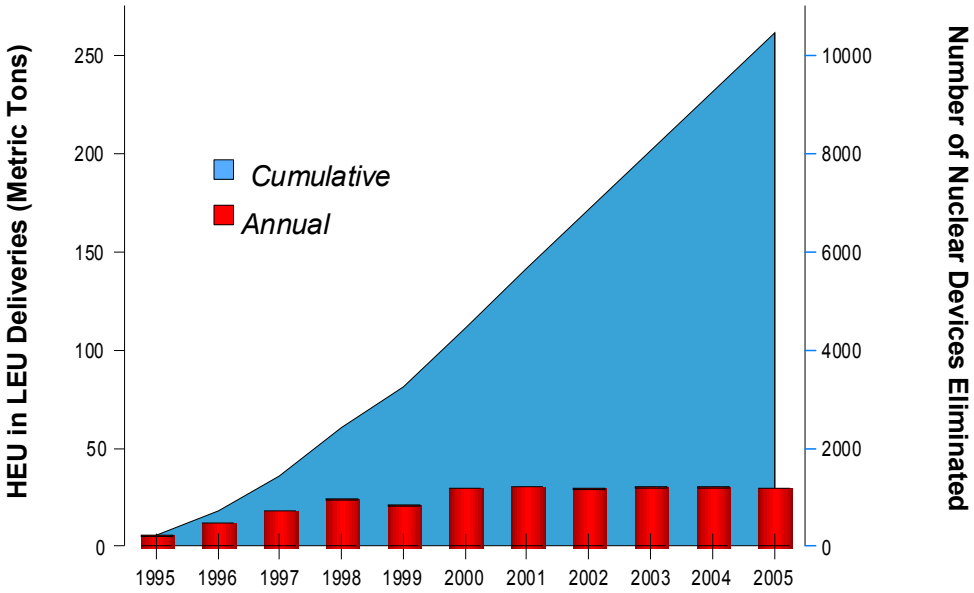
US and Russian monitors at Global Nuclear Fuel-Americas

US and Russian monitors at the Framatome-Richland Plant

* Ceased fabrication operations in 2001.

Program Milestone: 50% of the HEU Has Been Eliminated

Weapons-usable HEU Eliminated



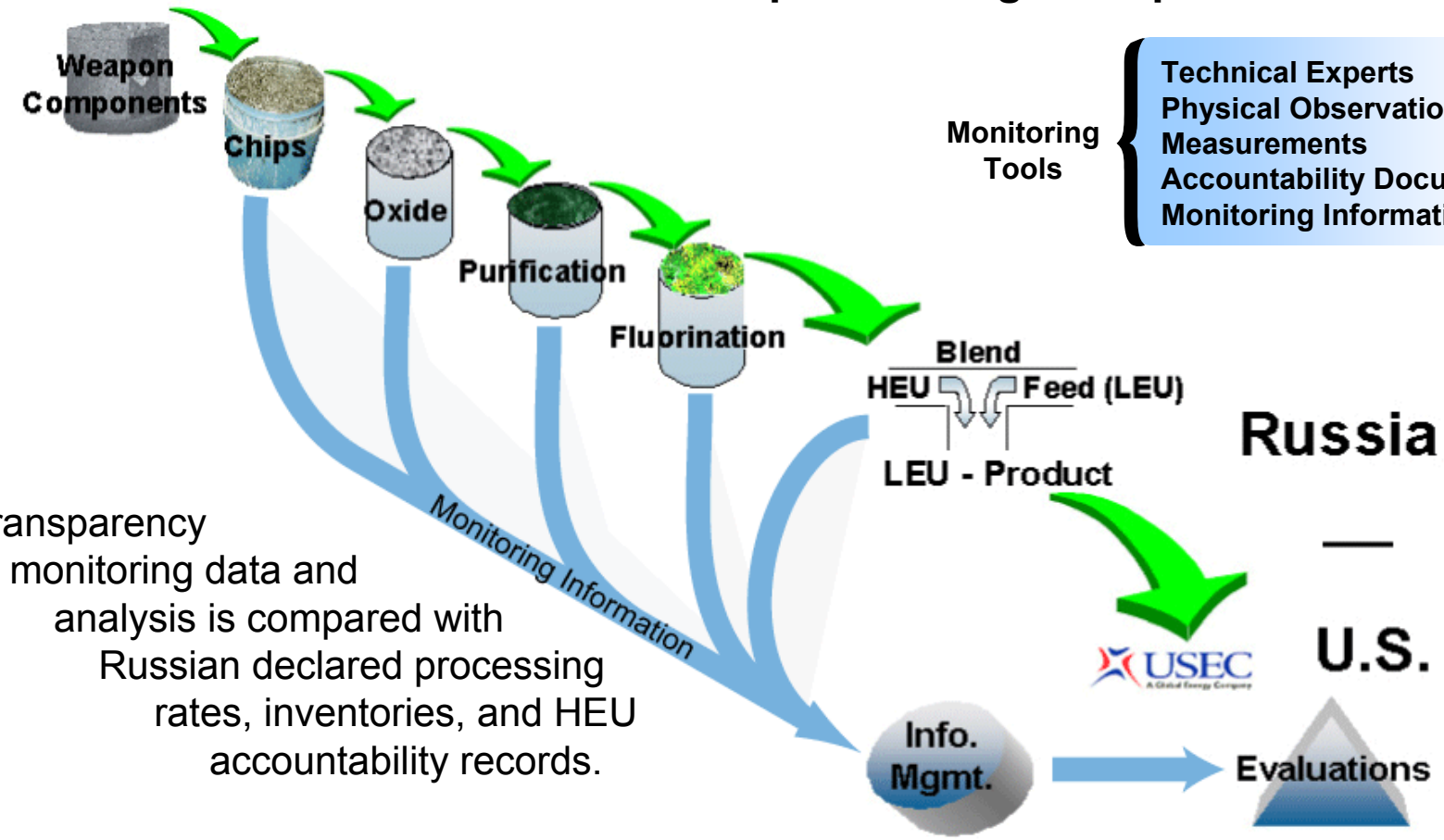
30 MT HEU Annual Conversion Rate (2000-2013)

- **Through December 2005, HEU-TP has monitored the conversion and blending of 261.7 metric tons (MT) of HEU used to produce the LEU delivered to US Enrichment Corporation.**
- **261.7 MT of HEU is equivalent to 10,467 nuclear devices*.**
- **Russia has delivered a total of 7670 MT of LEU containing 48.1 million SWU and 78.7 thousand MT of natural uranium.**
- **Conversion of 500 MT HEU into 15,000 MT of LEU should be completed in 2013 under the 20-year contract.**
- **500 MT of HEU is roughly equivalent to 20,000 nuclear devices*.**

*** Per IAEA standard for significant quantity of nuclear material**

HEU Transparency Information Process

Monitors gather data on material processing rates and material containers in Russian plant storage and process areas.



Monitoring Tools

- **Technical Experts**
- **Physical Observations**
- **Measurements**
- **Accountability Documents**
- **Monitoring Information**

Transparency monitoring data and analysis is compared with Russian declared processing rates, inventories, and HEU accountability records.

HEU-TP Monitoring Activities to Assure Nonproliferation Objectives are Met

Monitors annually conduct up to 24 Special Monitoring Visits to Russian uranium processing plants and staff a Transparency Monitoring Office (TMO) at UEIE to gather data on material processing rates and material containers in storage areas.

Monitors in uranium hexafluoride storage facility at SChE

Portable Nondestructive Assay (NDA) Instrumentation is used to determine assay of HEU in Russian containers.

Monitor uses NDA equipment at Russian plant

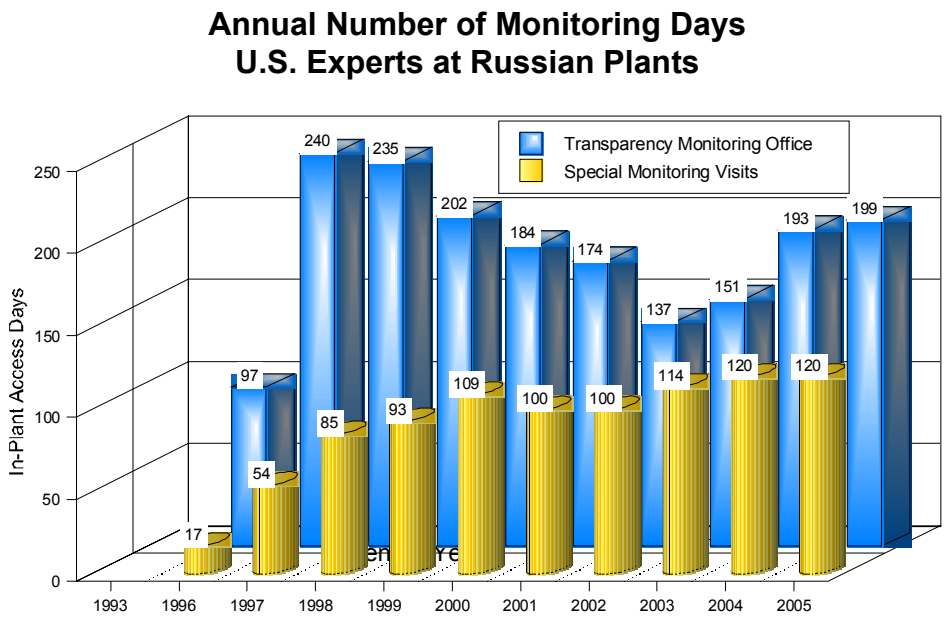
The U.S. designed Blend Down Monitoring System (BDMS) confirms the traceability, flow and enrichment assay of HEU being blended into LEU. The BDMS was installed at UEIE in January 1999.

Additional BDMS units were installed at ECP in February 2003 and at SChE in October 2004.

Monitors at the Control Cabinets for the two BDMS units at UEIE

Monitoring data and analysis are compared with Russian declared rates and inventories for consistency and accuracy.

HEU-TP Monitoring Trips In Russia



- In CY 2005 there were 24 Special Monitoring Visits (SMV) to four Russian processing plants and 12 monitors assigned to the Transparency Monitoring Office (TMO) at UEIE.
- From 1993 through 2005:
  - 184 SMV trips
  - 151 TMO monitor trips
  - 12 familiarization trips
  - 4 natural uranium inventory trips
- 24 SMV trips are scheduled for CY 2006.
- 14 TMO monitors are scheduled for CY 2006.
- Maximum coverage allows 24 SMV trips per year and a TMO staffed up to 12 months per year.

HEU-TP Observations

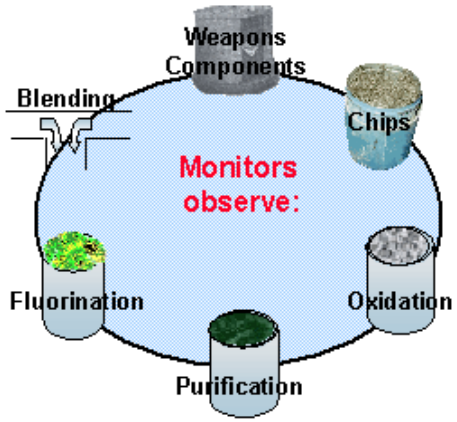
What is performed?

- Expert observation of process
- Tracking selected containers
- Compare observation and forms with process

30B cylinder (left) for LEU and cylinder overpack for transportation

What is observed?

- Process equipment used
- Process facilities and material
- Nuclear material accountability documentation



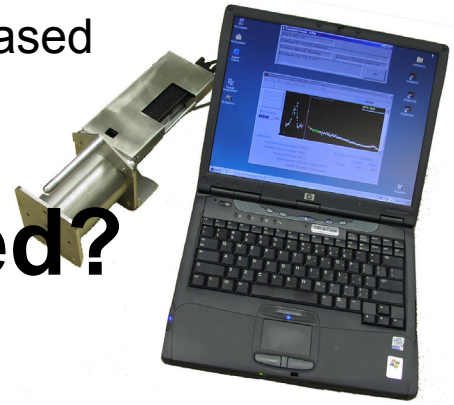
Where?

- All four facilities

HEU-TP Non-Destructive Assay (NDA) Testing

What is used?

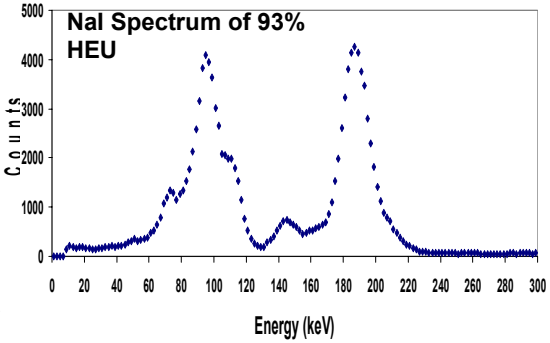
- Portable sodium lodide (NaI) based measurement equipment



Monitors using portable NDA testing equipment at MPA

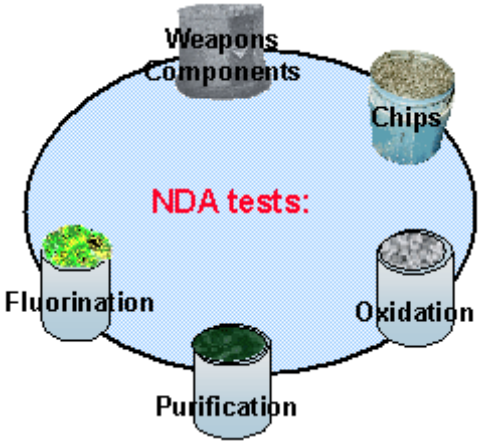
What is measured?

- Assay of HEU in closed containers



Where?

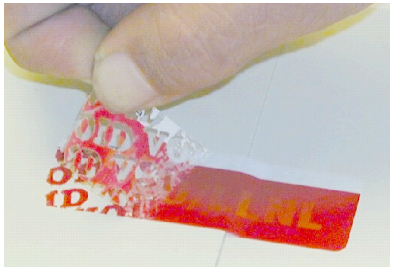
- All four facilities



HEU-TP Tags and Seals

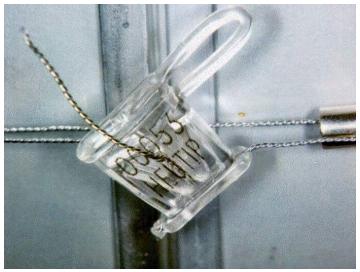
What is used?

Mylar/tape seal



E-cup seal

Quickseal



What is measured?

- Tamper indications for:
  - *NDA units, BDMS*
  - *Transport of HEU container (chain of custody)*
  - *Orifice plates*

Where?

- All four facilities

HEU-TP Blend Down Monitoring System (BDMS)

What is performed?

- The system can confirm the traceability of HEU being blended into LEU.
- Confirm uranium flow and enrichment assay.
- It cannot determine HEU origin.

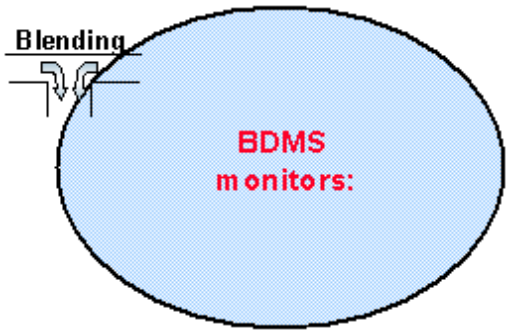
What is measured?

- Uranium assays
  - *HEU, LEU feed, & LEU product*
- Uranium flow rates
- Traceability: HEU to LEU

Where?

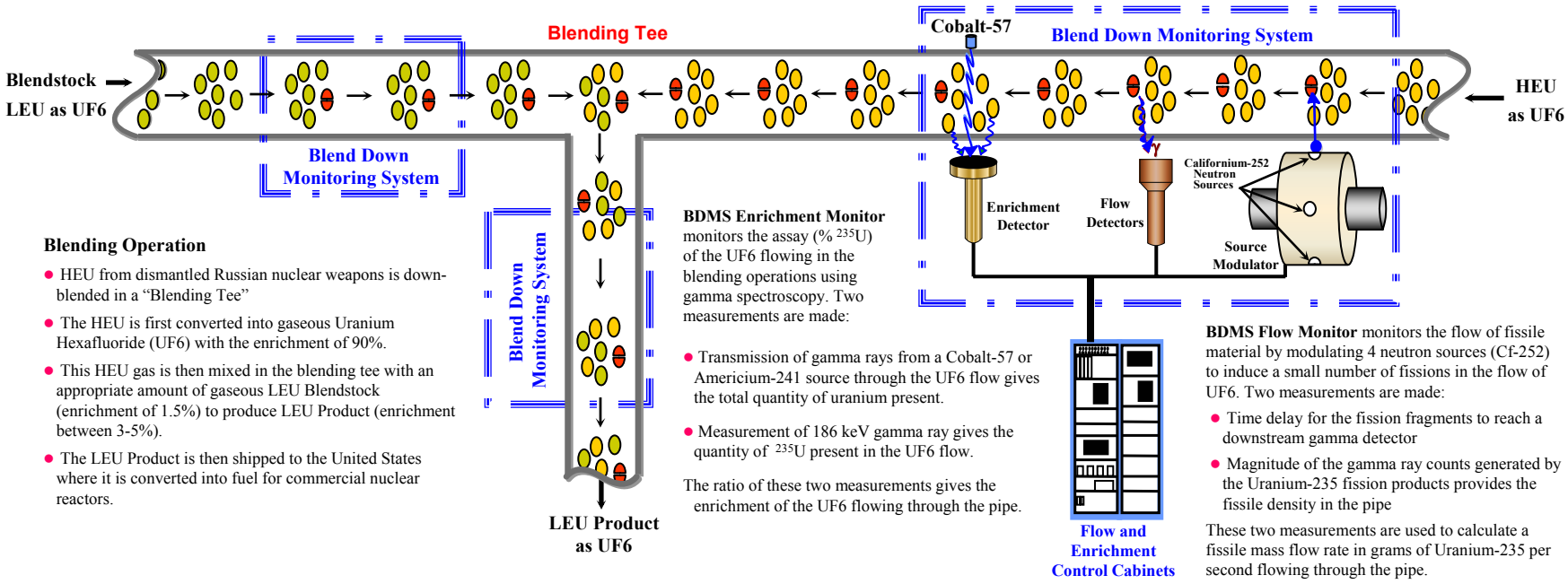
- UEIE - Installed January 1999
- ECP - Installed February 2003
- SChE - Installed October 2004

Monitors at ECP blend point with installed BDMS equipment



Blend Down Monitoring System

System designed in the USA and used in Russian Plants



Blending Operation

- HEU from dismantled Russian nuclear weapons is down-blended in a "Blending Tee"
- The HEU is first converted into gaseous Uranium Hexafluoride (UF6) with the enrichment of 90%.
- This HEU gas is then mixed in the blending tee with an appropriate amount of gaseous LEU Blendstock (enrichment of 1.5%) to produce LEU Product (enrichment between 3-5%).
- The LEU Product is then shipped to the United States where it is converted into fuel for commercial nuclear reactors.

BDMS Enrichment Monitor monitors the assay (% ^{235}U) of the UF6 flowing in the blending operations using gamma spectroscopy. Two measurements are made:

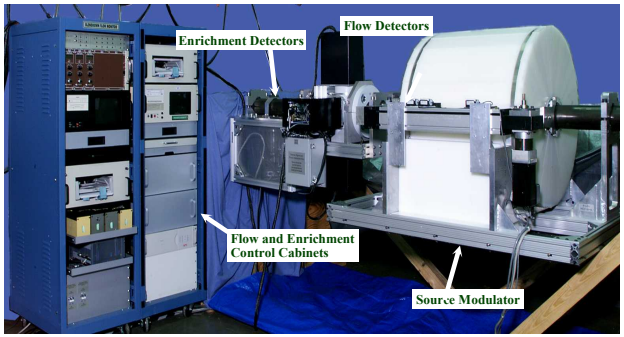
- Transmission of gamma rays from a Cobalt-57 or Americium-241 source through the UF6 flow gives the total quantity of uranium present.
- Measurement of 186 keV gamma ray gives the quantity of ^{235}U present in the UF6 flow.

The ratio of these two measurements gives the enrichment of the UF6 flowing through the pipe.

BDMS Flow Monitor monitors the flow of fissile material by modulating 4 neutron sources (Cf-252) to induce a small number of fissions in the flow of UF6. Two measurements are made:

- Time delay for the fission fragments to reach a downstream gamma detector
- Magnitude of the gamma ray counts generated by the Uranium-235 fission products provides the fissile density in the pipe

These two measurements are used to calculate a fissile mass flow rate in grams of Uranium-235 per second flowing through the pipe.

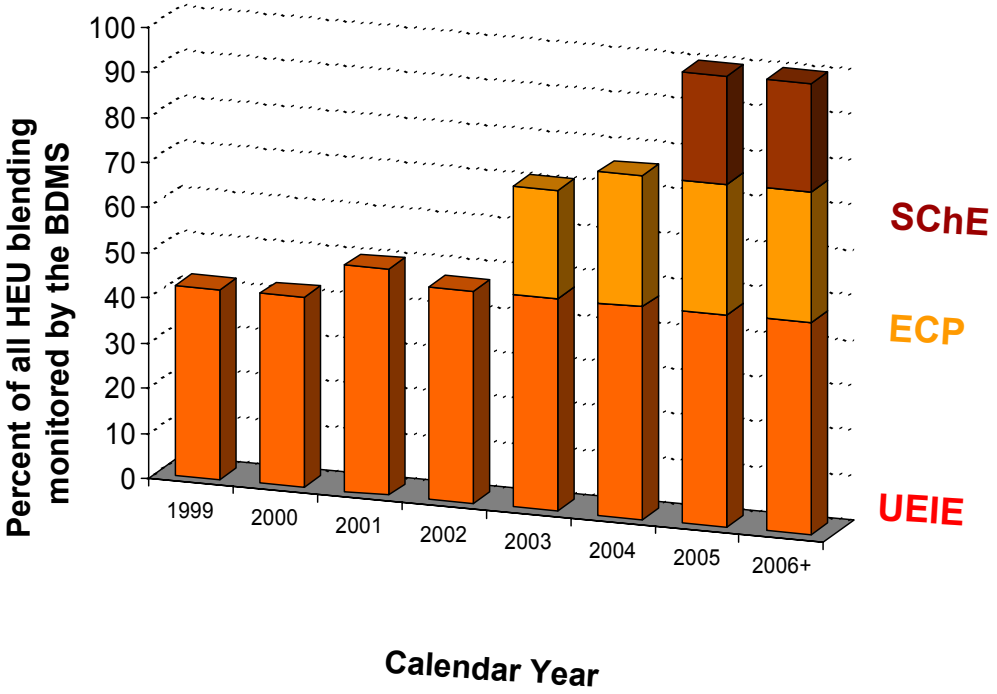


Role of the BDMS in the HEU Transparency Program

- The BDMS significantly increases confidence that HEU is blended into LEU Product by monitoring continuously the following items through the blending operations:
  - **Enrichment** assays:
    - Uranium Hexafluoride (UF6) in the HEU line
    - LEU Blendstock Line
    - LEU Product Line
  - **Mass flow** rate of fissile material
  - **Tracing** the flow of HEU

The BDMS monitors blending of HEU at All Three Russian Blending Plants

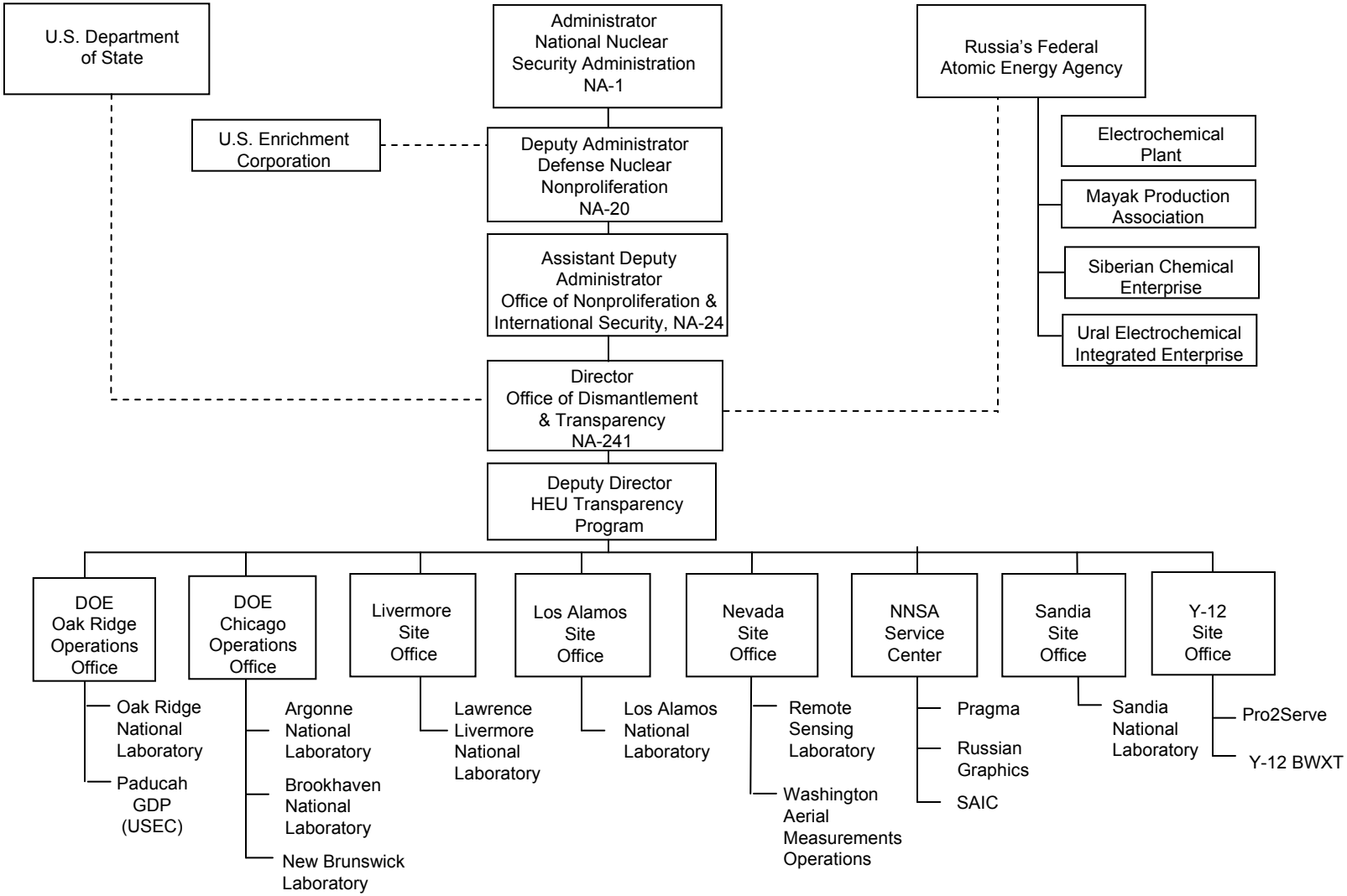
- The BDMS now provides 100 percent monitoring of HEU down blended into LEU at all three plants.
- Source changes are an ongoing operation.



- BDMS was installed at **UEIE in January 1999** and certified in August 1999.
- BDMS was installed at **ECP in February 2003** and certified in March 2003.
- BDMS was installed at **SChE in October 2004** and certified in February 2005.

Radioactive sources for the BDMS equipment are being supplied by the Russian Federal Nuclear Center-Institute of Technical Physics (Chelyabinsk-70)

DOE/NNSA Organization and Coordination



HEU-TP Accomplishments
for Calendar Year 2005

- *Surpassed the 50% milestone in the amount of HEU downblended to LEU and delivered to the United States.*
- *Conducted 24 SMV trips to the four Russian HEU processing plants for a total of 120 days. (A total of 184 SMV trips were conducted from 1996 through the end of 2005.)*
- *Twelve TMO monitors staffed the TMO for a total of 199 days.*
- *Weighed and validated HEU content of 91% of the HEU cylinders received at UEIE, or about 40% of all HEU processed at the Russian plants.*
- *Performed about 3,900 measurements using portable NDA equipment to confirm the ^{235}U enrichment in more than 3,200 Russian HEU containers and cylinders.*
- *Operated second-generation NDA units at all of the Russian sites.*
- *Monitored HEU blended down at UEIE, ECP, and SChE with the BDMS. Certification for operation of the BDMS at the SChE was completed in February 2005.*
- *Received, archived and processed 6500 pages of Russian facility process records and material control & accountability records.*
- *Operated a secure database and communications system connecting 13 sites in the United States, which centralizes and manages monitoring activities and data.*
- *Analyzed monitor observations and Russian declarations to build confidence in the achievement of our nonproliferation objectives.*
- *Coordinated Russian Transparency visit to 3 U.S. facilities in October 2005*

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