A "Proof of Concept" Demonstration of Radio Frequency-Based Technologies for UF_6 Cylinder Tracking at a Centrifuge Enrichment Plant

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Presented at the JAEA-IAEA Workshop on Advanced Safeguards Technology for the Future Nuclear Fuel Cycle

November 13-16, 2007

Agenda

- **Benefits for tracking UF_6 cylinders**
- **Cylinder Tracking System Goals**
- **Work Completed to Date**
- **A "Proof of Concept" Cylinder Tracking System Demonstration Project**
- **Current system components**
- **Future issues and concepts**
- **Conclusions**

Safeguards Benefits

- **Timely Detection of Diversion for Declared Cylinders**
  - Increased inventory efficiency by rapid positive ID of cylinders for IIVs and PIVs
  - Enhanced material flow verification and item tracking
  - Remote monitoring and timely access to information at IAEA HQ
  - Easily detect changes in cylinder attributes (such as tare weight)
- **Detect Production of LEU from Undeclared Feed**
  - Detect presence of untagged cylinders and undeclared activities in F&W areas when combined with other process monitoring and safeguards systems
- **Detect Undeclared Production of HEU**
  - Detect presence of undeclared cylinders in combination with other C/S systems for cascade areas
- **Additional Benefits**
  - Improve data accuracies (human error typical up to 10%)
  - Provide capability to track cylinders between sites
  - Track cylinders throughout their life cycle
  - **Potential to reduce frequency of on-site inspections**

Other Benefits of Cylinder Tracking

- Improve the effectiveness and efficiency of inventories
- Potential for developing dynamic site models that integrate data from other sensors and systems
- Provide enhanced time/date/location information for improved verification and analysis
- Eliminate the cost and complexity of wire-based systems
- Radio Frequency (RF) devices can be built to monitor other attributes such as tamper, motion, radiation, etc.

Cylinder Tracking System Goals

- **Overarching goal: Increase IAEA inspection efficiency and effectiveness,**

  reduce costs, if possible, and provide possibility for remote, secure access to IAEA authenticated data

- **Provide the capability to track the movement of all cylinders within an enrichment facility**

  including feed cylinders, parent product (or intermediate) cylinders, customer cylinders, sampling containers, and tails cylinders

- **Develop a unique, robust, and tamper-resistant RF device**

  that can be attached to each cylinder either before it enters the enrichment facility or at the point of entry

- **Ensure RF devices and attachment can survive and do not interfere with operational requirements**
- **Ensure data integrity and system reliability**

Work Completed To-date

- Developed preliminary functional and operational system requirements for a CTS
- Completed a preliminary RF tag vendor survey and procured tags for testing and evaluation
- Developed a conceptual system design
- Completed preliminary environmental and performance testing
- Identified operating site for “Proof of Concept” field testing
- Engaged other U.S. National Laboratories and developed a comprehensive path forward
- Put together system for “Proof-of Concept” testing and will soon begin to install at site

COTS Component Testing: Preliminary Conclusions

Only 2 of the 13 RF tags tested survived the single cycle of environmental testing with acceptable physical and performance characteristics

- However, most tags could be read even after extensive physical deformation
- Only the tags protected with a thick ceramic or ceramic-like coating were unaffected by the heating test

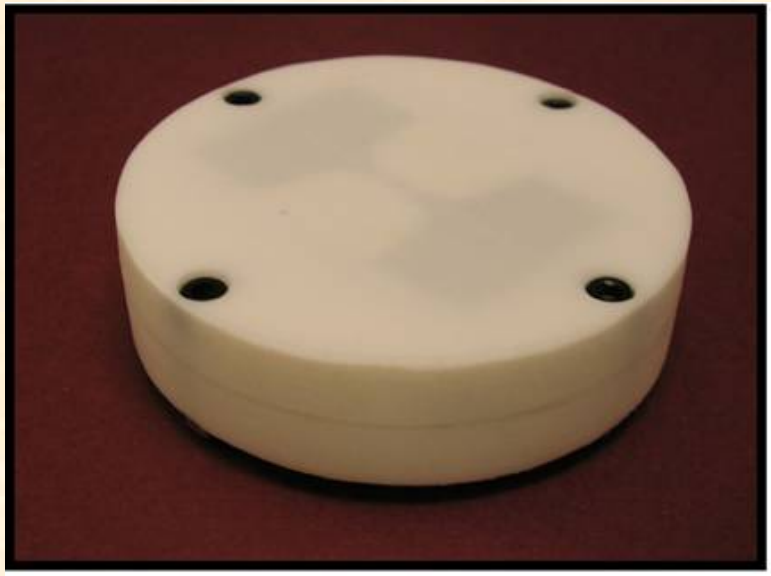
Not all the tags complied with industry-established RF formats

The size (i.e., surface area) of the antenna used by the reader system significantly affects the distance at which the tags can be read at maximum gain

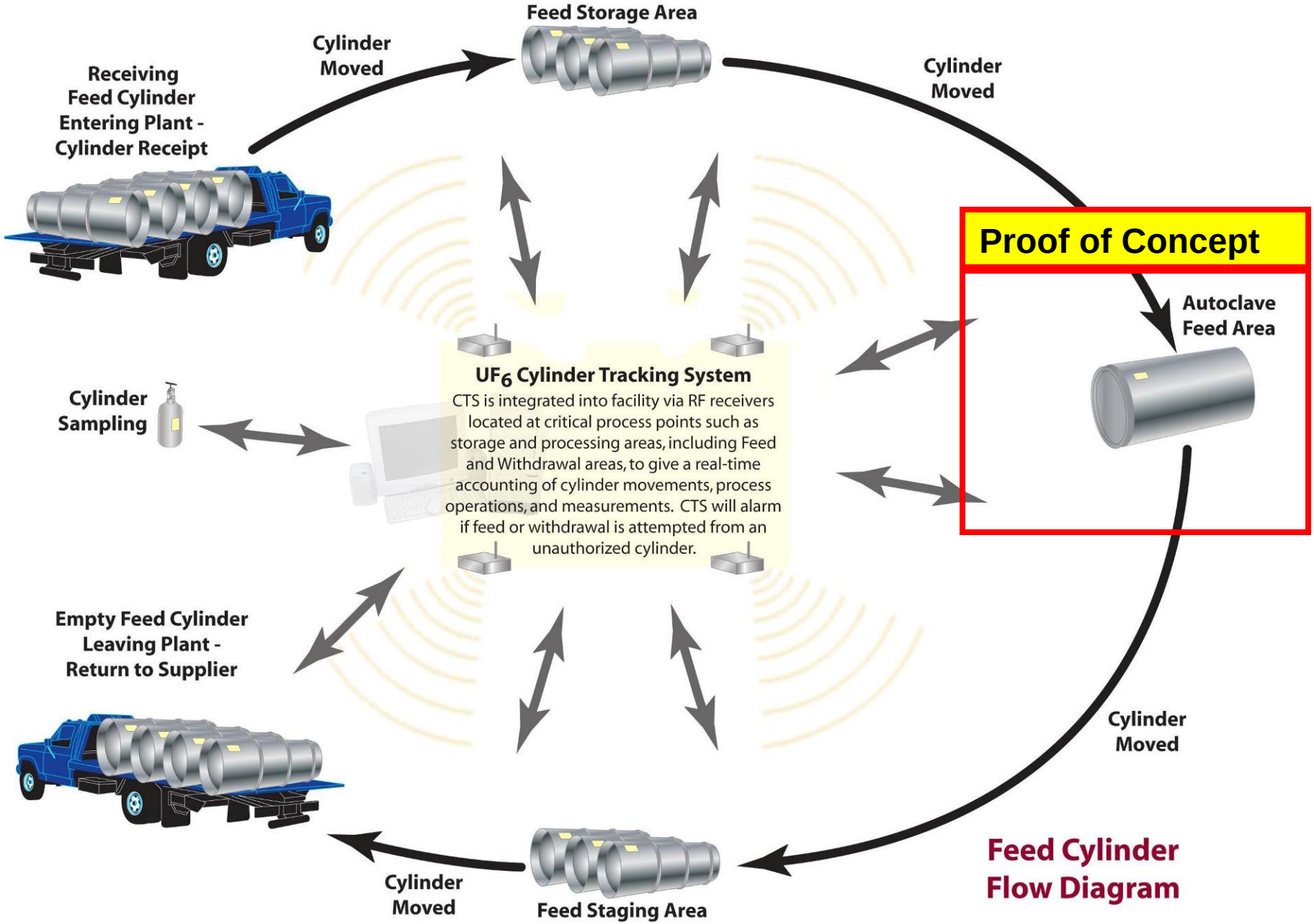
- Standoff height between the RF tag and the metal cylinder proved to be critical to minimizing metal interference
- There was generally good consistency in the read data for the tags

Current Work: Testing at an Operating Facility

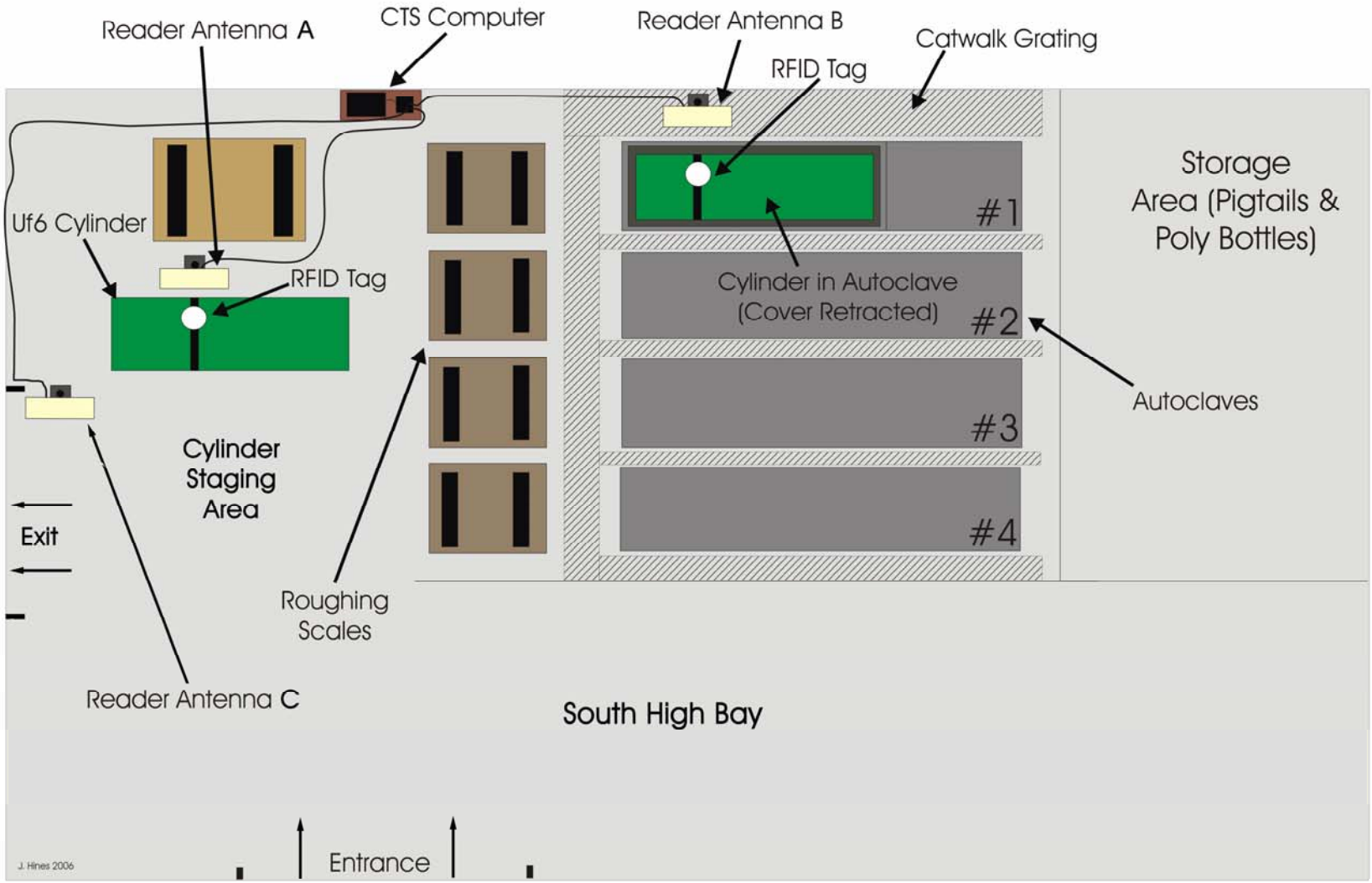
- None of the tags met all of the CTS performance requirements, so *improved RF tag designs will be needed*
- Some vendors expressed a willingness to develop custom tags
- A prototype passive RF Gen2 tag has been developed for further testing
- Custom high-temperature enclosure
- Read range at 90º on metal is approximately 7+ feet
- Passed preliminary environmental testing of -40º C and +140º C



Real-Time UF_6 Cylinder Tracking System (CTS)



Proof of Concept Demonstration

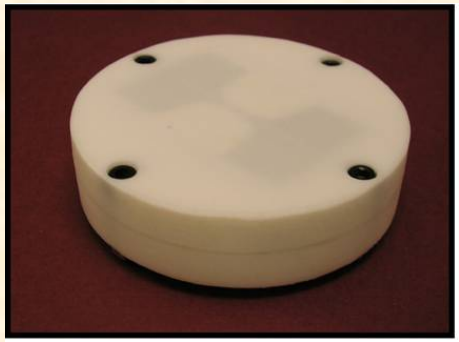


System Components for CTS Proof of Concept Demonstration

Autoclave antenna mounting

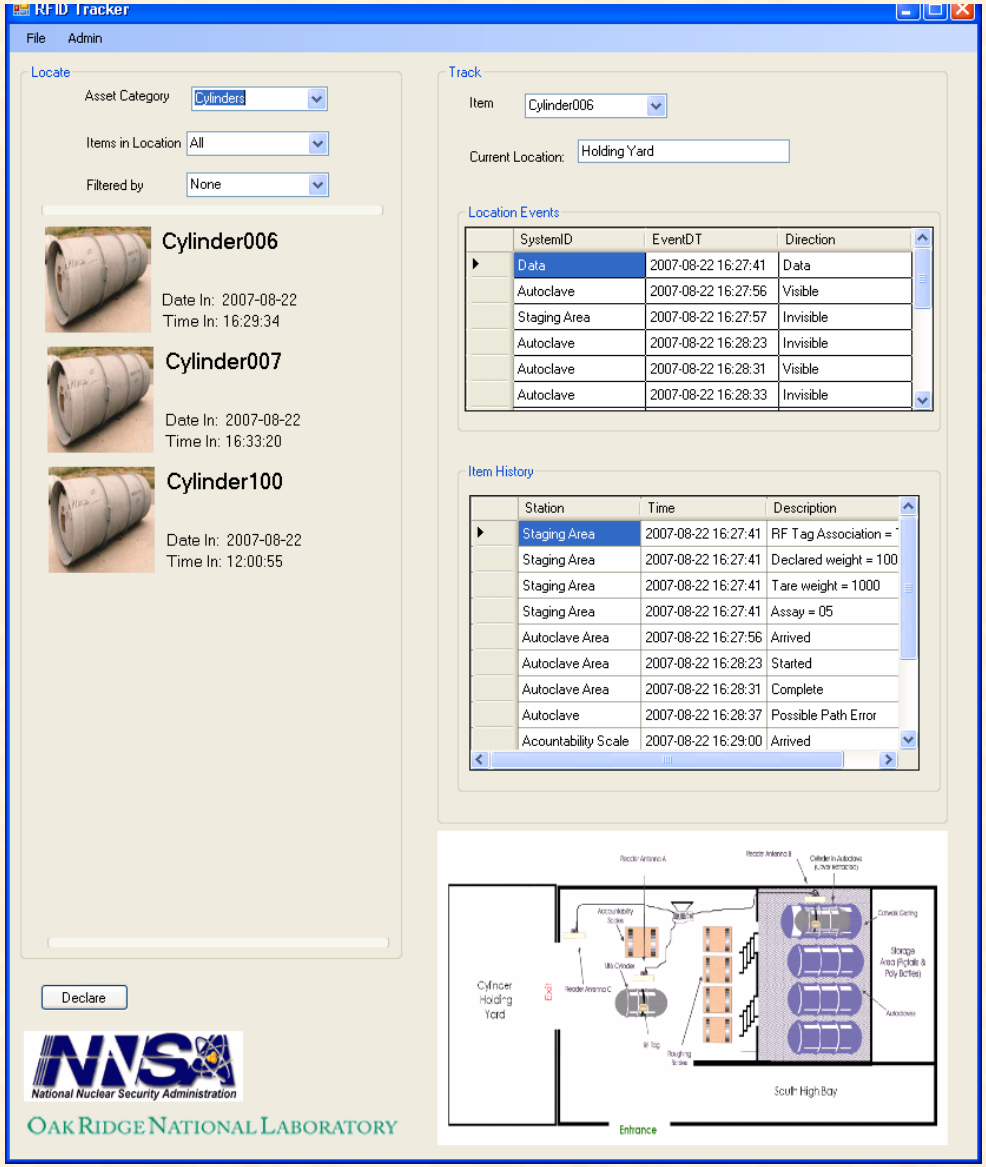
Scale antenna mounting

RF Reader that supports up to 4 antennas



Thermally protected RF Tag

Current User Interface



- **Modern data management features**
- **Built for growth**
- **Not technology specific**
- **Supports data authentication**
- **Rules-based event processing**

Testing at Operating Facility

- **Conduct the "proof of concept" test at an operating U.S. facility**
  - Demonstrate survival in a real-world operating environment of an enrichment facility
  - Evaluate operational performance and durability of RF tags and system components
  - Test hardware and software performance
  - Identify user issues/needs
  - Test rules-based approaches
  - Identify safety concerns (e.g., autoclave drain plugging)
  - Develop a more comprehensive set of system requirements
  - Define next phase testing
- **Lessons learned will be applied to full CTS design and integration**

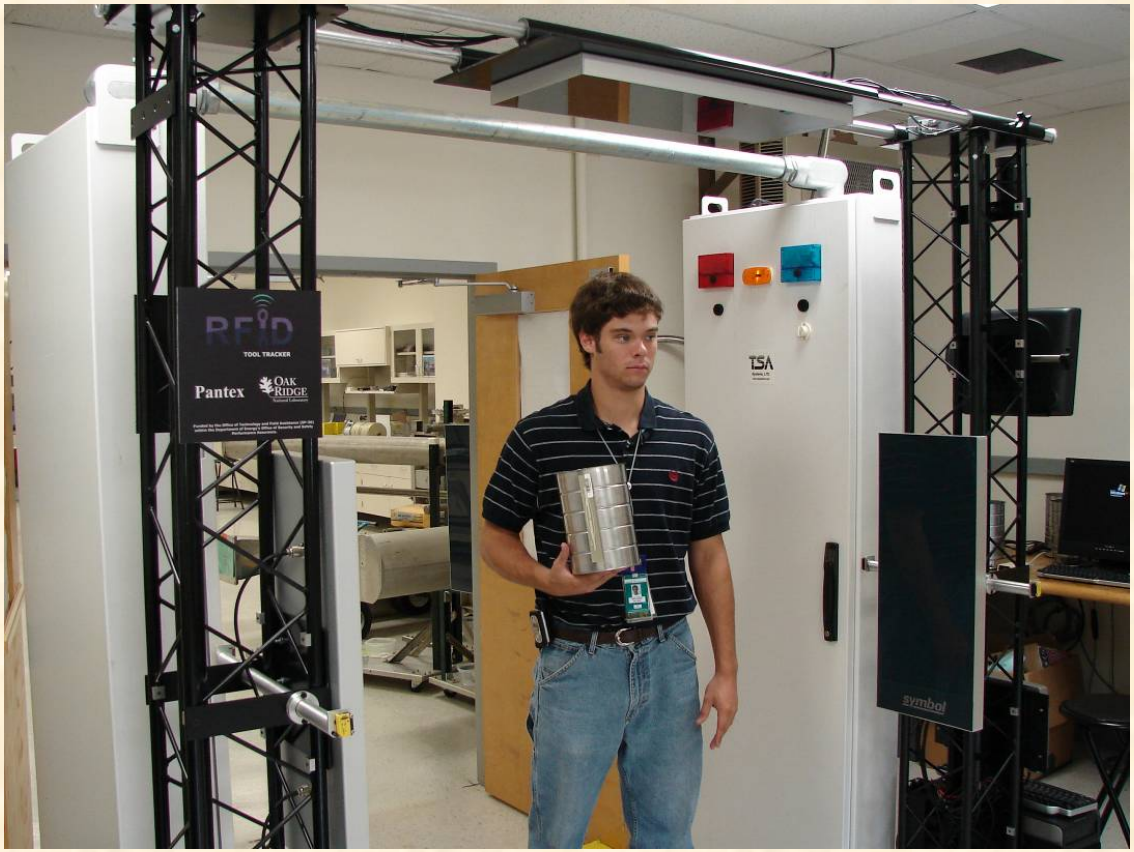
Issues To Be Addressed For Future RF-Based CTS

- **Cultural issues** - Cultural resistance to using wireless technologies exist largely because of questions regarding security and reliability
- **Security and vulnerability issues** - Vulnerabilities include spoofing, counterfeiting, transfer, and cloning. Sophisticated encryption techniques can mitigate these concerns. Must look at CTS as a part of a “defense in depth” approach in conjunction with other systems
- **RF interferences** - RF signals may interfere with existing systems and equipment

Issues To Be addressed For Future Efforts

- **Frequency limitations** - The frequencies allowed for use at a facility or in a country must be known and factored into a system using RF
- **Tags versus seals** - Criteria for when to use RF-based tags versus RF-based seals are needed. These criteria should include a design-based threat analysis and a cost-versus-performance evaluation
- **Reliability** - Reliability of RF technologies must be compared with current approaches and existing systems. Tags must be durable enough to survive the environmental and operational environments at a facility
- **IAEA authentication** - The system must be certified in a manner that assures the IAEA that the system is operational and the data is trustworthy

Future Concepts: Integration of the RF and Radiation Portals at Key Measurement Points



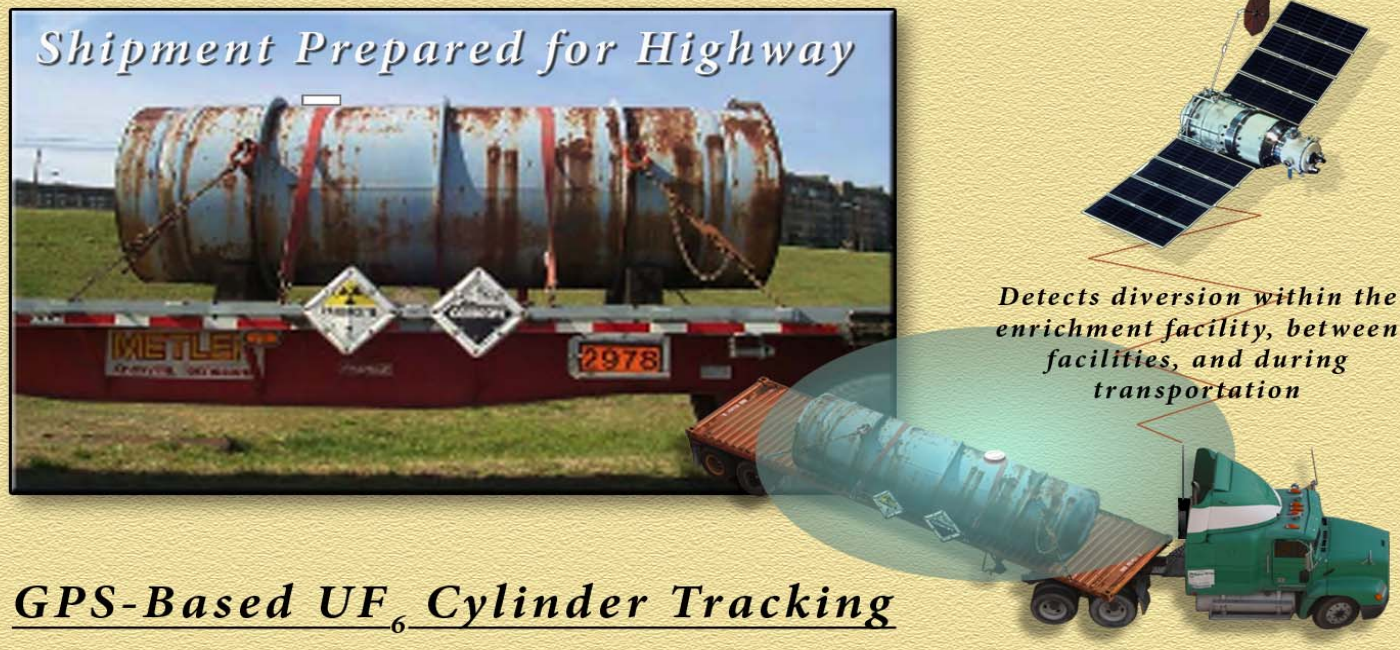
- Direction
- Occupancy
- Gamma/ neutron levels
- Item ID
- TID status
- Camera

The RF-Base TID (Enabling Technology)

- Single-use plastic strap passive RFID E-seal with reusable electronics
- Records data when it is armed: last time read, tamper-event information
- Real-time clock: temperature sensor
- EPC Global Generation 2, Class 1+ tag
- Operating frequency range: 860-960 MHz
- Read range: 21 feet
- Operating temp: -40°F to 158°F
- Humidity: 95% non-condensing at 158°F

Passive RF-based Seal

Future Concepts: Link with GPS



GPS-Based UF_6 Cylinder Tracking

- When a UF_6 cylinder is loaded onto the transport vehicle, the RF system on the vehicle communicates with the RF-reader to verify that the correct cylinder has been loaded.
- The tagged cylinder RF-identity number is stored in RF-GPS system on the vehicle.
- The GPS system communicates with the satellite during transit and provides authentication of the identity of the tagged UF_6 cylinder to a central database.

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Conclusions

- Developing a CTS is highly relevant when considering increasing emphasis on nuclear power and enrichment services
- Limited IAEA budget growth - technology can be a part of the solution
- Operators and IAEA will need to cooperate to help solve the problem
- Operators must be open to new technologies such as RF devices and consider dual benefits
- Such technologies should be incorporated early in the design of new facilities for most efficiency

Final Remarks

- There are several pros and cons associated with RF-based technology and it is important that operational, security, and performance requirements are well known and evaluated before a technology is selected
- Many operational issues can be overcome but real world site specific performance tests are a must
- Rules-based systems can be set up to enhance “near real time” detection and trigger other devices or systems to respond
- Good system design and evaluation methodologies must be utilized, along with stringent (in the field) operational and performance evaluations