Radiological Source Tracking in Oil/Gas, Medical and Other Industries: Requirements and Specifications for Passive RFID Technology

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Radiological Source Tracking in Oil/Gas, Medical and Other Industries:

A Requirements Document for Passive RFID Technology

I. SUMMARY

Subsurface sensors that employ radioisotopes, such ^{241}Am-Be and ^{137}Cs, for reservoir characterization must be tracked for safety and security reasons. Other radiological sources are also widely used in medicine. The radiological source containers, in both applications, are small, mobile and used widely worldwide. The nuclear sources pose radiological dispersal device (RDD) security risks. Security concerns with the industrial use of radionuclide sources is in fact quite high as it is estimated that each year hundreds of sealed sources go missing, either lost or stolen. Risk mitigation efforts include enhanced regulations, source-use guidelines, research and development on electronic tracking of sources. This report summarizes the major elements of the requirements and operational concepts of nuclear sources with the goal of developing automated electronic tagging and locating systems.

Previous exploratory studies have already demonstrated that RFID monitoring and tracking systems have the potential to increase the security and safety in the usage of radioactive sources. To develop mature deployable advanced RFID monitoring and tracking system for the tracking of radionuclide sources, there is a need to specify the technical requirements on RFID tags and readers – requirements that would allow widespread adoption of this technology in source tracking applications. In this report, we focus on passive RFID (PRFID) systems, where the sensor is battery-less and therefore with an indefinite lifetime, a sensor feature that is highly desirable for cost-effective long-term and reliable wireless non-line-of-sight monitoring.

As we are concerned with passive RFID sensor tags and reader designs, we need to first discuss the industrial usage and handling of such radio-isotopes with respect to oil/gas (for both well-logging and LWD) and medical applications of radiological sources. The report first briefly discusses the need of radio-isotopes in various tasks and their respective operational practices. The discussions on industrial operational tasks and end-to-end lifecycle phases of radioisotope sources lead to technical requirements for the components of a passive RFID tracking systems. Those

technical requirements, in turn, are expected to lead to technical design constraints such as sensor size and shape, sensor read range, sensor lifetime, and various other environmental factors that the tag needs to operate without breakdown.

The main requirements for PRFID, with respect to the applications of interest, are summarized in Tables 1 and 3.

II. TECHNOLOGY REQUIREMENTS

2.1 Background: Passive RFID in Tracking

In this document, we are considering the use of passive RFID tags in oil/gas and medical applications for tracking radiological sources. Recent developments in the design of passive RFID tags have led to new opportunities in using these small, low-cost battery-less electronic labels for tracking and inventory of nuclear sources in many applications, including oil/gas exploration, nuclear medicine, food industry, and construction. This report discusses the technical requirements that need to be addressed in employing passive RFID tags on nuclear sources – a problem of significant importance and technical challenges. An important objective is the tracking of sealed sources, instead of tracking just source containers. The design of RFID tags for source holders is especially challenging because of the limited space available on tiny source holders that are attached to the metallic logging tools: the tags need to be electrically *very* small. Although tagging and tracking large containers during transportation has been addressed by others with battery-powered *active* sensors or *active* tags, our objective in this project is to extend the capabilities of *passive RF tags* for tracking during radio nuclide *source* transportation without the need for batteries. Tracking sources, rather than tracking containers, poses non-trivial technical challenges because passive tags are battery-less; however, passive tags have important advantage over active tags in terms of the maintenance and tag life times.

2.2 Scope of the Report

This report is based on numerous discussions with industry users, reviewing large number of references, and performing a limited set of laboratory and field tests. We briefly discuss the sources employed, operational tasks, and chain-of-custody risks associated with down-hole well-logging, nuclear medicine, and then outline the key requirements needed in closing gaps and identifying roadblocks to implementation. (See Appendix C for a FAQ on the NSTS).

The set of specifications in this working document is based on the following six categories of requirements:

1. Embedded Tag Design: The design is depended on the object to which the PRFID tag is attached or embedded – this limits the size, shape, and antenna design of the tag; and respective location of the readers;

2. Monitoring State: State of source to be tracked: stationary, mobile, or during use;

3. Operational Environment: Background environmental conditions (heat, radiation, etc.)

4. Data Type and Communications: What type of data is logged during monitoring – data bandwidth and frequency of queries – and communication and database requirements; read and write requirements; security;

5. Read Range and Search Capabilities: Recovering lost or orphan sources and real-time inventory (i.e. need for geo-location);

6. Cost of Implementation: Cost of tags and a monitoring system are quite important in commercial applications.

2.3 Source Monitoring in Oil/Gas Industry

In nuclear well-logging, radiological sensor devices employ gamma and neutron data (“logs’) from wells drilled deep into the ground to determine whether the well has the potential to generate oil or gas. The radionuclide-based subsurface devices have been an integral part of the suite of other instruments sent downhole to determine the porosity and lithology, two important petro-physical parameters used in estimating hydrocarbon reserves and in designing well-completion for safe operation, and ultimately making hydrocarbon production decisions [Ellis 1987].

The oil/gas well logging mostly use two types of radioactive sources: neutron sources and gamma ray sources: ^{137}Cs and ^{241}Am-Be. ^{137}Cs-based tools measure formation density which provides the most accurate estimate of total porosity. ^{241}Am-Be source tools are used to measure the apparent neutron porosity which helps identify gas in conjunction with density and delineate the lithology. The ^{241}Am-Be source-based spectroscopy tools allow mineralogy determination [Herron and Herron 1996]. Mineralogy information is becoming increasingly important in assessing unconventional (primarily shale) reservoirs. Despite having built-in safety features and their utilization in compliance with all governmental transport and handling regulations, it has been recognized that radionuclide logging sources can pose serious safety and security risks from inadvertent exposure or lost sources.

To fully appreciate the security concern for these rather powerful nuclear sources used in well-logging, it is useful to discuss how the sealed sources are stored, transported, and deployed during operations. Figure 1 shows a conceptual diagram for end-to-end monitoring of sources in oil and gas applications.

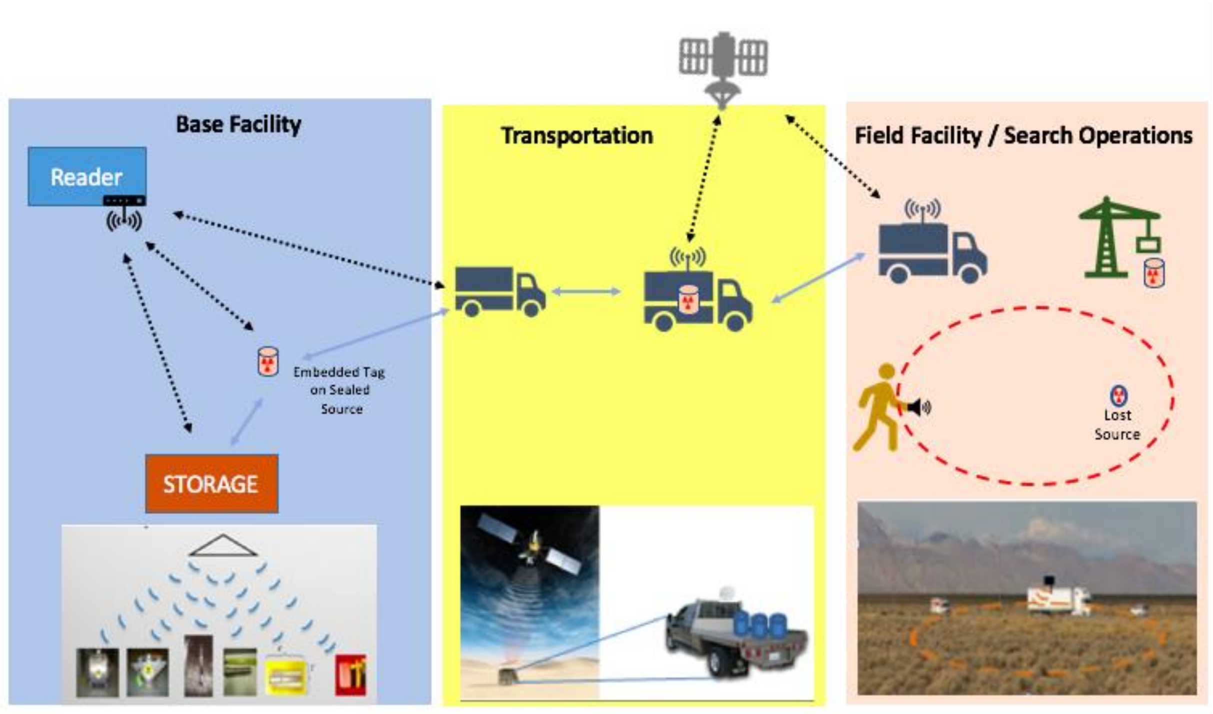

Figure 1: In Oil/Gas exploration the use of RFID and its technical design parameters and requirements are based on monitoring and tracking of sources in the facility area lab and storage, during transportation, and at field operation sites. Embedded tags on sealed sources are very

small, and there might be a need to install multiple readers at waypoints in the laboratory and storage areas. The source can be tracked during transportation with communication between tag readers and satellites. Sources can also be traced and monitored at the field sites with readers.

Figure1 shows the conceptual diagram of chain-of-custody for nuclear sources at the storage facility or inventory monitoring(left), monitored transportation (middle), delivery of sources to the field, and search for lost sources in the field (right).

Figure 2 shows how sealed sources are packaged, stored, handled and inserted into the logging tools, transported to the field site, and deployed into the wells. An RFID system must be designed to track and monitor all these states of operations.

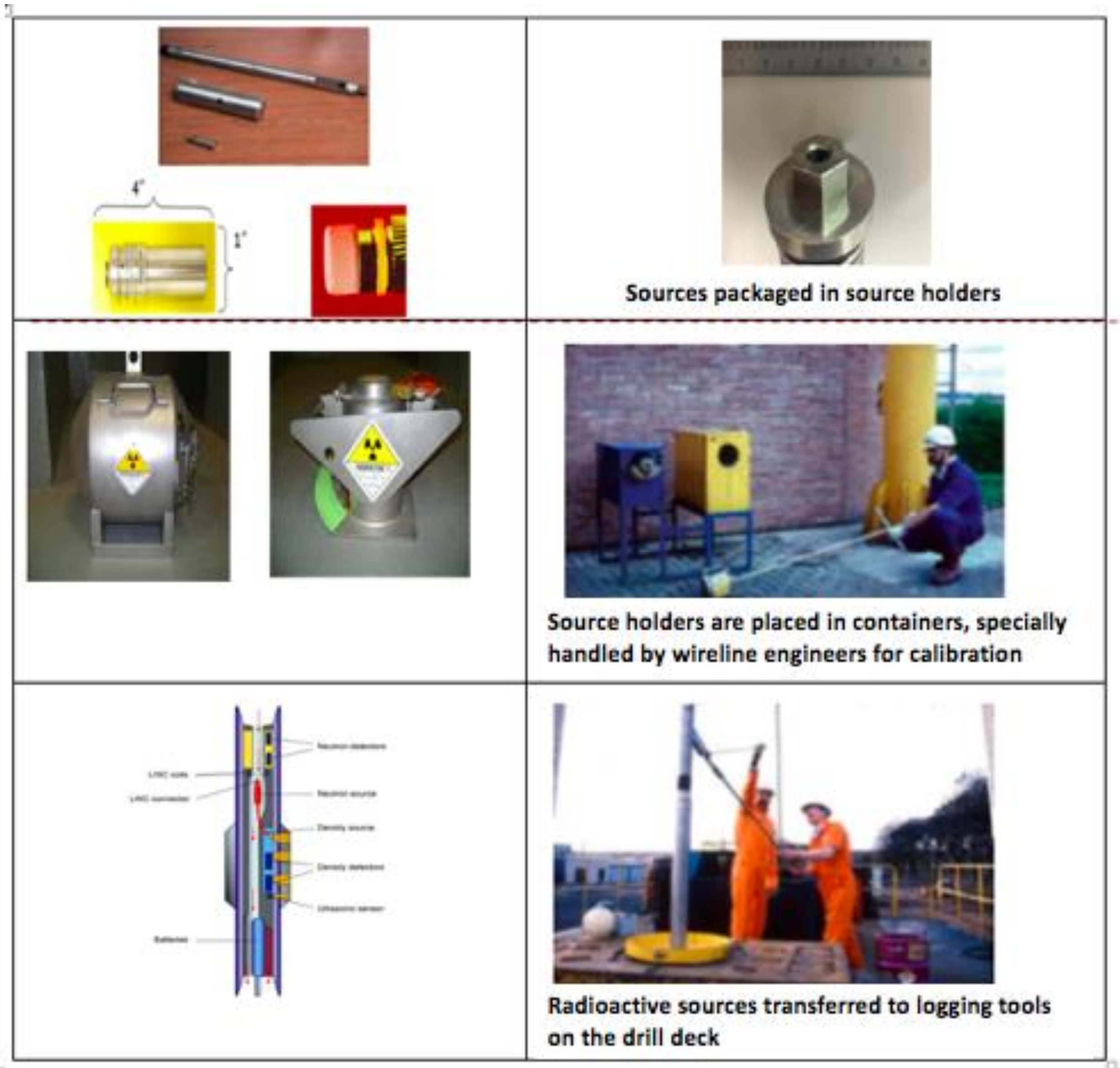

Figure 2: (Top left) Typical density and neutron source capsules. Their small size is noteworthy. (middle left) Each capsule is placed in appropriately designed respective shielded container, such as those for transportation to the field. (bottom left) Source holders are transferred to logging tools.

In all the above operations, the radioactive sources are vulnerable to loss, theft, and misplacement. Operators need to keep detailed and accurate records on where are the sources at all times, both to prevent accidental exposure or unauthorized disposal. In offshore platforms and rigs, records of onshore data are needed in search and recovery in the event of accidents. Radiation sources not accounted for, must notified promptly on any loss. Lost or orphaned sources constitutes serious hazard and security risks. The oil/gas users community are particularly interested in overcoming some of the following problems:

- Failure to report transactions;
- Inaccurate reporting of transactions;
- Reporting multiple sources as a single source.
- Searching for lost sources at the field sites or during transportation.

An RFID system designed specifically for source tracking can easily handle the above issues, as it is an automated tracking system. To meet these needs, several technical requirements need to be specified for an RFID system at various waypoints shown in Figure 2 for reliable and real-time monitoring. These technical needs consist of:

(1) Size and shape limitations of the sensor tags on the sealed sources;
(2) Importance of long lifetime for RFID tags and sensors;
(3) Placement of the tag on sources;
(4) Ability of tags to work reliably in harsh environments including heavy metallic, radioactive and extreme heat and pressure;
(5) Readers location with respect to the sources for effect monitoring;
(6) Intervals for monitoring messages and database for on-demand tracking;
(7) Networking, for real-time monitoring during transportation, centralized database;
(8) The need for other sensor data besides RFID identification;
(9) Searching of lost sources and search parameters;
(10) Portable readers for search operations;

(11) Readers with GPS and GIS connectivity for cellular and satellite tracking in the field.

With respect to the environmental requirements, the tags need to be quite rugged for well-logging applications. (On the other hand, for medical applications, the environmental specifications are not difficult to meet.)

- Tolerances: Temperature of 150-175^{o}C under normal operating conditions and pressure conditions of 20,000 psia or higher. Note that these are lower than the requirements identified by the end users.
- Shock and vibration tolerances need to be high; for example, in LWD 1000G *s*hock and vibrations of 5-500 Hertz at 20 g rms.
- Total tool length should be less than 12 ft., and the tool outer diameters could range from 1.7 to 3.5 inches. However, the source holder in only a few centimeters long.

After several discussions with industrial user community, it was particularly clear that in addition to inventory monitoring of sources, the retrieval of lost or misplaced sources is of great importance, and a problem that RFID can fill an important gap. Sources are often transported between service company base and points of use. The sources might also be redirected or transferred to new locations, moved from temporary storage and assigned a new field site.

Table 1 summarizes the key requirements for use of RFID in oil and gas industry.

Table 1: Key Requirements for Oil/Gas End-Users

Attribute		Requirements
1. Embedded Tag Design	Field	Long lifetime (years), no maintenance, tolerant of high temperatures, vibration, and pressure
	Storage	Long lifetime (years), no maintenance
2. Monitoring State	Stationary/Mobile	Stationary monitoring is of primary importance specially in storage and waypoints. However, monitoring during transport is highly desirable.
3. Operational Environment	Temp	As high as 600 degree F (downhole)
	Pressure	30,000 psia (downhole)
	Humidity	0 - 100%
	Radiation	Medium (need further quantitative studies)
4. Data and Communication Requirements	Working life	>1000 hours
	Capacity	~ 10's Kbps (based on logs used – see Appendix A and B)
	Networking	Highly reliable, no dead times due to battery lifetimes
5. Read Range Search Capability	Stationary Field Search (within FCC limits)	Monitoring ~ 20 feet Search ~ 100 feet
6. Cost of Implementation		Use cost is complex: will include rig time, decision time, personnel, cost of stuck tools, etc. Tags < $100

2.4 Source Monitoring for Nuclear Medicine

There is concern that in a medical setting, unsecured and open facilities pose a security threat. In a medical or university, the physical control and accounting of radioactive sources might be insufficient as the material is typically stored with minimal or no physical protection, and the facilities are often open to large number of people. The use of RFID as a monitoring or inventory system would be quite useful in these facilities. In particular RFID can address cradle-to-grave controls on radioactive materials. Lack of controls have led to what is called “orphaned” radioactive sources and present both safety and security risk, just as in the oil/gas exploration field.

Today most major hospitals have a nuclear medicine department, and it has been estimated that about one-third of all patients admitted to U.S. hospitals will need radioisotope treatment or diagnosis. And over a 100 million radiation therapy are performed annually. In nuclear medicine, the radionuclides used have a short half-life (6-hour for Tc-99m, used for diagnosis of osteoporosis). Examples of most commonly used radionuclides are shown below in Table 2:

Table 2: Commonly used radionuclides in Medicine

Radionuclide Source	**Half-life**
Technetium-99m (Tc-99m)	6 hours
Iodine-131 (I-131)	8 days
Flourine-18 (F-18)	110 minutes
Cobalt-60 (Co-60)	5.271 years

Other radionuclides used in medicine are gallium-67 and thallium-201 to diagnose the functioning of the heart, brain, lung, kidney, or liver. However, because of the short half-life the radiopharmaceuticals must be produced, shipped, and used within a couple of weeks. On the other hand, Co-60, another commonly used radionuclide (used for sterilization of medical equipment), has a half-life of over 5 years. Co-60 is also used in teletherapy units to destroy malignant tumors with gamma radiation. Yet another use of radionuclides is in the brachytherapy, where sealed needle containing iridium-192 or iodine-125 is inserted directly into the cancerous tissue. Brachytherapy and teletherapy procedures are performed by trained medical personnel and strict controls and safety requirements are set by NRC. In these settings, treatment rooms must have adequate shielding to prevent scattered radiation into adjacent rooms.

Figure 3: Gamma camera used to detect dysfunctional activity in body organs

Other Industries

While we have considered only oil/gas and medical industry, radionuclides are also used in food industry and construction industry. These industries use very specialized structures in their use of sources (see Figure 4 below) and the number of units are limited. Although this study did not focus on food and construction industry, preliminary investigations suggest requirements of oil/gas industry will meet the requirements of these industries.

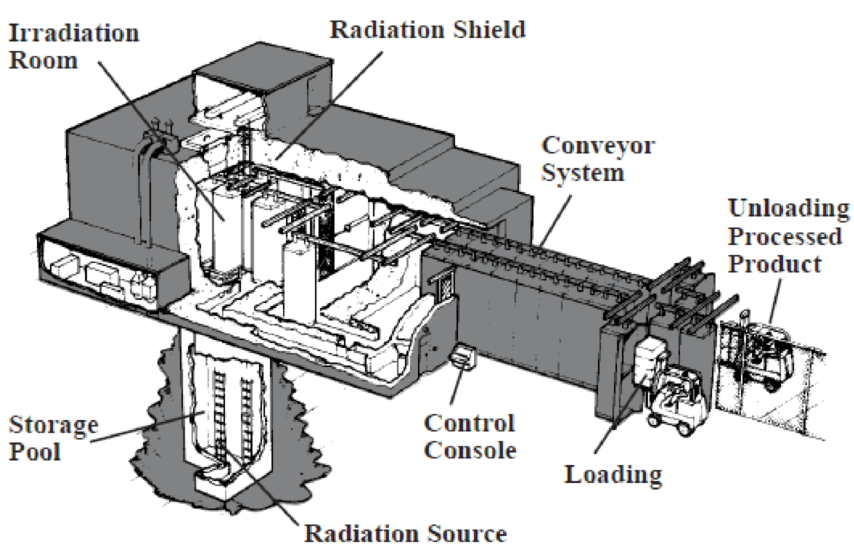

Figure 4: Industrial irradiators used for food products consists of a room with concrete walls 2 meters thick and a radiation source (co-60). The source can be lowered to the bottom of the pool. In food industry, sterilization improves food safety. Massive amounts of high-activity cs-137 and co-60 are used in facilities for food sterilization and preservation. [From: "*The Regulation and the Use of Radioisotopes in Today's World,"* NRC 2000 report].

Radioactive Source Handing in Nuclear Medicine

With a brief review of the importance of nuclear medicine, we now focus on what the technical steps towards integrating an RFID system for the tracking of medical radiopharmaceuticals. From the viewpoint of tracking and monitoring of radionuclides in a medical setting, the problem essentially reduces to one of inventory and record-keeping. Figure 5 shows a conceptual diagram of nuclear source monitoring in a medical facility.

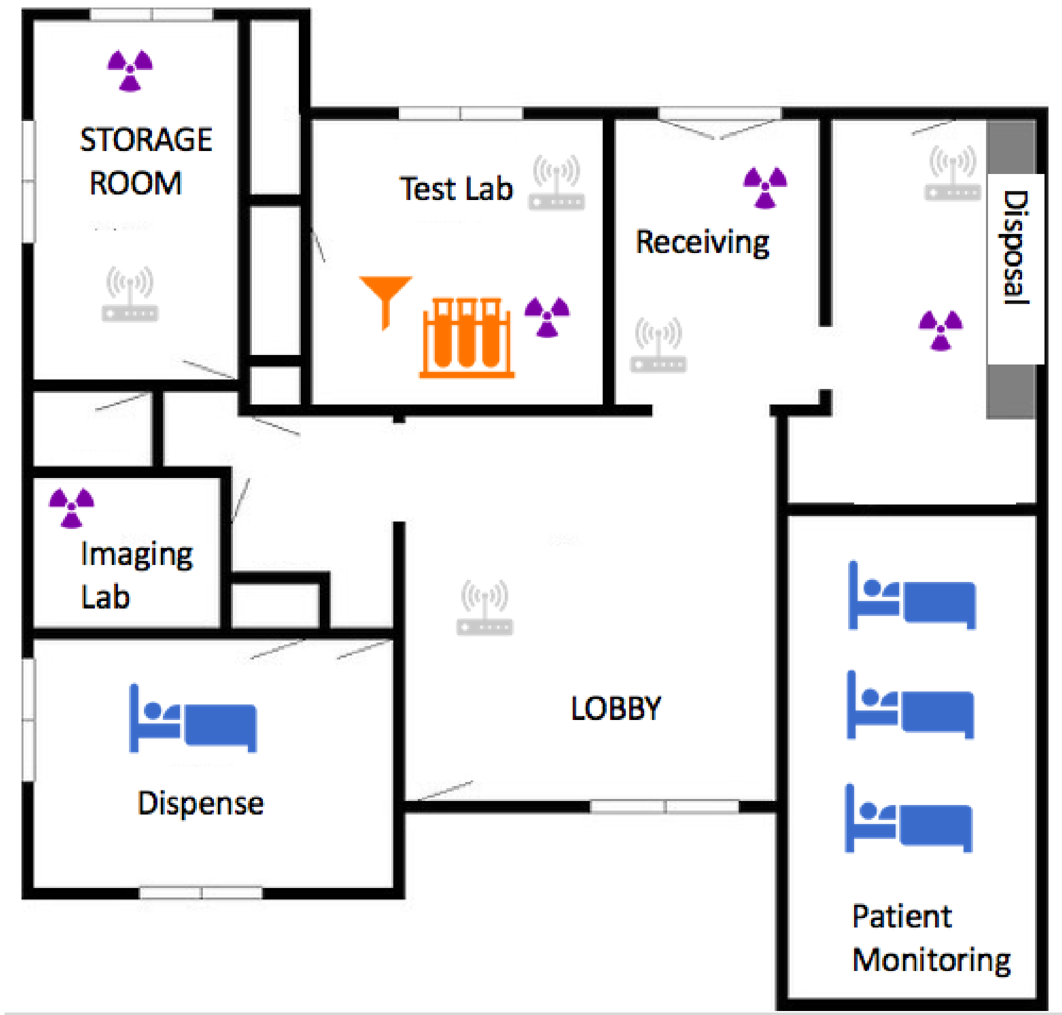

Figure 5: Use of RFID tags and readers for tracking radioisotope in a medical setting. In medical applications, the use of RFID and its technical design parameters and requirements are based operations in a hospital setting and based on the specific hospital building plan. In this problem, read range and tag size are less of an issue. A wireless network can track and monitor sources in storage, labs, imaging, and waste disposal areas with a centralized database.

To develop an end-to-end RFID based monitoring system it is useful to understand the usage and disposal techniques of radionuclides in a hospital setting. The use of radioisotopes and disposal of radioactive waste is governed by the guidelines issued by international and national regulatory organizations. The procurement, usage and disposal of radioactive waste from the regulatory body is mandatory. There is vast literature of documents that spell out the rules and regulations for radionuclide handling in medicine. It is useful to outline the handling of radionuclides in a medical setting and these steps can be broadly described as:

1. Receiving of radioactive sources and radiopharmaceuticals:

   Order, receipt, storage and inventory control of radioactive drugs (radiopharmaceuticals), other drugs used in nuclear medicine, and related supplies. (Hand-held RFID systems can useful in this task.)

2. Preparation, Tests and Storage

   Preparation of radiopharmaceuticals by combining radioisotopes with reagent kits, and compounding radiopharmaceuticals that are not commercially available; appropriate tests and storage of radio nuclides. (Portal RFID systems can useful in this task.)

Figure 6: Example storage cabinets of radionuclides in a hospital.

3. Dispensing. (Hand-held and/or portal RFID systems can useful in this task.)
4. Radioactive waste disposal (Hand-held and/or portal RFID systems can be used).

Figure 7: Example waste storage of radionuclides in a hospital.

The following sections is a summary of operational procedures from references in the bibliography. By looking at the practices in hospitals (*see below: (i)-(vi)*), the requirements on use of RFID monitoring techniques does not pose any technical challenge, expect possible the design of embedded tags on cylindrical bottles, test-tubes, and specialized reader. In fact, current passive RFID systems can readily by integrated with the disposal process outlined below. The tags can be RFID label tags, the size of a postage stamp, and the readers can be a strategic portals or handheld readers. The key would be the integration of a RFID reader with a centralized networked or cloud database for record keeping. To develop an end-to-end RFID based monitoring system it is useful to understand the usage and disposal techniques of radionuclides in a hospital setting. In the following is a brief outline from operational procedures and practices in hospitals *(see below: (i)-(vii) – from multiple IAEA reports cited in the reference section).* We include these set of requirements because they directly lend insight for RFID technology requirements.

(i) ***"Sealed Sources for Dispensing:*** *Hospitals use sealed sources for a variety of applications, including teletherapy, brachytherapy, blood irradiation, calibration etc. Most of these sources are relatively small with activities ranging from a few up to a few hundred MBq, except the teletherapy and blood irradiation source, which may have high activities. Once the source becomes weak for further applications it has to be removed and replaced. Hospitals ordering and using such equipments must enter into a contract for safe removal and replacement of the sealed radioactive source with the suppliers. While ordering such equipment and the source, the Radiation Safety Officer of the hospital should be taken into confidence.*

(ii) **Collection**: *The hospital radioactive waste is mostly composed of low level waste and occasional medium level waste with short half-lives (half-life less than a month). The high-level waste is usually associated with nuclear industry and nuclear reactors. The radioactive waste should be identified and segregated within the area of work. Foot operated waste collection bins with disposable polythene lining should be used for collecting solid radioactive waste and polythene carboys for liquid waste. Collecting radioactive waste in glassware should be avoided. Each package is monitored and labeled for the activity level before deciding upon the mode of disposal. Some hospitals that have incinerators and permission to dispose of combustible radioactive waste through incineration may also segregate combustible radioactive waste from non-combustible waste. When two different isotopes of different half-lives like Tc-99m and I-131 are used, separate waste collection bags and bins should be used for each. Each bag or bin must bear a label with name of the isotope, level of activity and date of monitoring.*

(iii) **Dilution**: *The radioactive waste is usually disposed by dilution is used in low activity solid radionuclides are disposed off as ordinary hospital waste provided the activity of the article does not exceed 1.35 microcuries or the overall package concentration does not exceed 135 microcuries /* m^3*. These objects include vials, syringes, cotton swabs, and the like. Similarly, liquid radioactive waste with activity less than microcurie level is disposed off into the sanitary sewerage system with adequate flushing with water following the disposal. However, the maximum limit of total discharge of liquid radioactive material into sanitary sewerage system should not exceed the prescribed limits.*

(iv) **Delay and Decay:** *This technique is used for medium activity radioactive waste and those with half-lives of less than a month may be stored. The storage room should be properly ventilated with an exhaust system conducted through a duct line to a roof top exit. The storage space should have lead shielding of appropriate thickness (10 HVL) to prevent radiation leakage. The radioactive waste is stored for a minimum period of about 10 half lives when after decay only 0.1% of the initial activity remains. The waste is then monitored for the residual*

activity and if the dose limit is low it is disposed off as low activity solid or liquid waste. Most of the low and medium level radioactive hospital waste is of short half-life permitting this type of waste disposal.

(v) ***Concentrate and Contain:*** *This technique of radioactive waste disposal is sometimes used for radioactive materials with very high activity levels and for those with long half-lives (longer than a month). Their disposal by delay and decay method is impractical because of longer storage period, particularly if space availability is limited. Radioactive waste is collected in suitably designed and labeled containers and then buried in exclusive burial sites approved by the competent authority. In day-to-day work of a hospital, we do not come across radioactive waste of this nature and as such, this method of radioactive waste disposal is rarely used.*

(vi) ***Incineration:*** *Insoluble liquid waste such as that from the liquid scintillation systems may be disposed off by incineration. Inceneration reduces the bulk of waste and the activity is concentrated in a smaller volume of ash for further disposal. Since incinerators used for radioactive waste disposal release part of the radioactivity into the atmosphere they should operate under controlled conditions and in segregated places. Ashes collected have to be disposed off as solid radioactive waste separately. Environmental concerns and public pressure severely restrict the methods of ground burial and incineration as regular options of radioactive waste disposal. For these reasons, incineration and burial are rarely recommended.*

(vii) ***Storage:*** *Radioisotopes are required to stored in lockable metal cabinets or refrigerators at designated locations within a laboratory. These controlled locations should be protected against unauthorized access. Proper storage of radioisotopes in the laboratory includes providing sufficient shielding to reduce emitted radiation level to the lowest possible (and certainly to below the legally prescribed limit of 1µSv/hr), and preventing the release or spillage of radioactive materials. Storage locations for radioactive materials, such as refrigerators, should be labeled with the "Caution Radioactive Material" signs. Storage* *containers and waste containers should also be labeled with "Caution Radioactive Material" signs.'’*

From the regulations above, we see that the monitoring and tracking of radionuclides in a hospital setting is somewhat different than that in oil/gas industry, although tag design requirements are similar. . In this setting, the short-lived radio isotopes are moved from station to station, stored in storage areas, and then moves on as waste products. In this problem, real time monitoring with read capabilities in certain rooms and portals are important, at same time wireless hand-held units integrated with a central database is critical. Fortunately, the environmental conditions are much more relaxed. However, tags embedded on test-tubes, bottles, or small source holders is still. The requirements are summarized in Table 3.1

Table 3: Key Requirements for Nuclear Medicine End-Users

Attribute		**Requirements**
1. Embedded Tag Design	Dispensing	Medium lifetime, no maintenance, tolerant of
	Storage	Long lifetime, no maintenance
2. Monitoring State	Stationary/Mobile	Networking monitoring in hospital is of primary importance specially in storage and waypoints. However, monitoring during transport is also highly desirable.
3. Operational Environment	Temp	Industrial standard
	Pressure	N/A
	Humidity	0 - 100%
	Radiation	Low (need further quantitative studies)
	Working life	>1000 hours

4. **Data and Communication Requirements**	Capacity	~ 10’s Kbps (based on logs used – see Appendix A and B)
	Networking	Highly reliable, no dead times due to battery lifetimes
5. **Read Range Search Capability**	Stationary Field Search (within FCC limits)	Monitoring ~ 30 feet Search ~ 30 feet
6. **Cost of Implementation**		Use cost is complex: will include rig time, decision time, personnel, cost of stuck tools, etc. Tags < $10

2.5 Conclusions

The requirements of PRFID for monitoring and tracking is dependent of the application field. While oil/gas exploration requires small tags built for harsh environments, nuclear medicine require small tags that are readable in a building facility including storage cabinets. In almost all applications networking and database are important attributes for operational usage. The ability to search for lost items is also of critical need. The main technical challenge is to design a build embedded tags on sealed source holders. An area of great interest is search of lost tags for all applications. And finally the ability to develop low cost system is quite important in all applications.

Acknowledgements

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Nomenclature/Acronyms

Am-Be: Americium-Beryllium

LWD: Logging-while-drilling

RDD: Radiological dispersal device

RFID: Radio Frequency Identification

PRFID: passive RFID

RDD: Radiological Dispersal Device (RDD, or "dirty bomb")

RED: Radiological Exposure Device

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Appendix A: NSTS Transaction Report

NRC FORM 748 (5-2012) 10 CFR 20.2207 — U.S. NUCLEAR REGULATORY COMMISSION

NATIONAL SOURCE TRACKING TRANSACTION REPORT

APPROVED BY OMB: NO. 3150-0202 — EXPIRES: 01/31/2016

Estimated burden per response to comply with this mandatory information collection request: 9.5 minutes. NRC requires this information to populate the National Source Tracking System for certain sealed sources. Send comments regarding burden estimate to the Records and FOIA/Privacy Services Branch (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects.resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0202), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

1. LICENSEE INFORMATION

A. LICENSEE NAME	B. LICENSE NO.	C. LICENSEE STREET ADDRESS	D. CITY	E. STATE	F. ZIP CODE

2. TRANSACTION DATE	3A. TRANSACTION INFORMATION	3B. TRANSACTION TYPE (Check all that apply)
(Only transactions completed on the same date may be reported together on this form)	☐ NEW ☐ CORRECTION IF CORRECTION, PREVIOUS TRANSACTION DATE:	☐ REPORT SOURCE INVENTORY ☒ TRANSFER ☐ RECEIPT ☐ DISPOSAL ☐ NEW SOURCE MANUFACTURED ☐ IMPORT ☐ EXPORT ☐ DISASSEMBLE

4. PREPARER INFORMATION

A. NAME OF PREPARER	B. DATE PREPARED	C. PREPARER PHONE	D. PREPARER E-MAIL (REQUIRED FOR CONFIRMATION)

6. SOURCE TRANSFER DATA

A1. RECEIVING LICENSEE NAME	B1. RECEIVING LICENSEE LICENSE NO.	C1. RECEIVING LICENSEE SHIPPING ADDRESS	D1. CITY	E1. STATE	F1. ZIP CODE

G1. SOURCE MAKE	H1. SOURCE MODEL	I1. SOURCE SERIAL NUMBER	J1. ISOTOPE	K1. ACTIVITY AND UNIT	L1. ACTIVITY DATE	M1. WASTE MANIFEST NO. (For waste shipments only)	N1. CONTAINER ID (For waste shipments only)

O1. ESTIMATED ARRIVAL DATE	P1. COMMENTS

WARNING: FALSE STATEMENTS IN THIS CERTIFICATE MAY BE SUBJECT TO CIVIL AND/OR CRIMINAL PENALTIES. NRC REGULATIONS REQUIRE THAT SUBMISSIONS TO THE NRC BE COMPLETE AND ACCURATE IN ALL MATERIAL RESPECTS. 18 U.S.C. SECTION 1001 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

Appendix B: Oil/Gas Source Tracking Logs

INSTALLATION SOURCE REGISTER

Details of all radioactive consignments, that is, sealed sources and unsealed substances arriving at and departing from the installation should be recorded. Use one line per consignment.

Service company	Source arrival date	Nuclide e.g. ^{192}Ir	Activity e.g. GBq, Ci	Physical form e.g. sealed, gas, liquid, powder	Source serial number	Storage location	Source disposal date	Disposal route e.g. beach, well number, rig transfer	Audit date

FIG. 18. Example of a record to account for radioactive sources.

Appendix C: National Source Tracking System (NSTS) FAQ

These FAQ from NSTS website is enclosed as it constitutes important information with respect to tracking sources on NSTS:

- **What sources are tracked by the NSTS?**

  Within the scope of the NSTS, the sources of interest are a subset of sealed sources, known as "nationally tracked sources." These sources contain quantities of radioactive material that are equal to or greater than the Category 2 Nationally Tracked Source Thresholds set forth in Appendix E to Title 10, Part 20, of the *Code of Federal Regulations* (10 CFR Part 20), "Standards for Protection Against Radiation." For example, nationally tracked sources include the individual sources in an irradiator, the sources used in a gamma knife, most radiography sources, some well-logging sources, and any other sources that meet the criteria for tracking. Nationally tracked sources do not include materials that are encapsulated solely for disposal, or any type of nuclear material contained in a fuel assembly, subassembly, fuel rod, or fuel pellet.

- **Are these sources specifically licensed? If so, why doesn't NRC already know who has them? Why is a tracking system needed?**

  Yes, licensees must have a specific license to possess these sources. Licenses typically establish the maximum quantities that a licensee may possess at any one time. However, licenses do not list the individual sources, although some licenses specify a device, or whether a specific source is still in the licensee's possession.

  A tracking system is necessary so that the Government may better monitor the location and movement of sources with high levels of activity. These sources could potentially be used in a radiological dispersal device (RDD, or "dirty bomb") or radiological exposure device (RED). The tracking system will provide better accountability for the sources.

The NSTS contains information on licensees who possess nationally tracked sources. This information is specified in 10 CFR 20.2207 and includes the name and address of the facility, the license number, and contact information (such as phone number and email address).

Information on each tracked source includes the make, model, serial number, radioactive material, and activity. The information will include records of transfers between licensees.

- **Who is responsible for providing the information to the NSTS?**

  All licensees possessing Category 1 and 2 sources are responsible for reporting information to the NSTS.

- **When these tracked radioactive sources are no longer in use, where do they go? In other words, is there an appropriate place for disposal of these sources?**

  There are many appropriate places for disposition of these sources. Some sources may be re-used or recycled when they are no longer needed by the owner. Some resources may be returned to the manufacturer or transferred to another licensee that has a need for the source. Certain sources may be required to be placed in secure storage at the licensee's facility or collected by DOE under the Offsite Source Recovery Program, until appropriate disposal is available. Other sources may be disposed of at a low-level radioactive waste disposal facility.

- **How does the National Source Tracking System make the general public safer from the malevolent use of radioactive materials?**

  First, licensees are required to report both shipment and receipt of nationally tracked sources transferred to another licensee. If the system does not receive a report of the shipped source being received as expected, it will alert regulatory authorities to investigate. This will result in prompt follow-up on missing sources, thereby improving the ability to detect their diversion and malevolent use in real-time.

Second, the NSTS allows origin-to-endpoint accounting of all nationally tracked sealed sources.

Finally, regulatory decision-makers have reliable data for use in long- and short-term planning regarding the use, storage, and disposal of nationally tracked sources. This capability did not exist prior to the development of the NSTS.