A National Tracking Center for Monitoring Shipments of HEU, MOX, and Spent Nuclear Fuel: How Do We Implement?

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A National Tracking Center for Monitoring Shipments of HEU, MOX, and Spent Nuclear Fuel: How do we implement?

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Abstract

Nuclear material safeguards specialists and instrument developers at US Department of Energy (USDOE) National Laboratories in the United States, sponsored by the National Nuclear Security Administration (NNSA) Office of NA-24, have been developing devices to monitor shipments of UF₆ cylinders and other radioactive materials¹, ². Tracking devices are being developed that are capable of monitoring shipments of valuable radioactive materials in real time, using the Global Positioning System (GPS). We envision that such devices will be extremely useful, if not essential, for monitoring the shipment of these important cargoes of nuclear material, including highly-enriched uranium (HEU), mixed plutonium/uranium oxide (MOX), spent nuclear fuel, and, potentially, other large radioactive sources. To ensure nuclear material security and safeguards, it is extremely important to track these materials because they contain so-called “direct-use material” which is material that if diverted and processed could potentially be used to develop clandestine nuclear weapons³. Large sources could be used for a dirty bomb also known as a radioactive dispersal device (RDD). For that matter, any interdiction by an adversary regardless of intent demands a rapid response.

To make the fullest use of such tracking devices, we propose a National Tracking Center. This paper describes what the attributes of such a center would be and how it could ultimately be the prototype for an International Tracking Center, possibly to be based in Vienna, at the International Atomic Energy Agency (IAEA).

Introduction

The concept and implementation of tracking using wireless capability have been around for decades. The best example of such a system is the worldwide air traffic control system, a unique and constant choreography of thousands of planes in the skies around the world (see Figure 1). The investment is staggering; yet, it is one that is not given a second thought by the public unless problems arise. In the US alone, the Federal Aviation Administration recently secured a budget of ~$19B per year⁴. How did such a system come about? Underlying that question is the public’s demand and expectation for safety and the realization that, without providing this safety, there would not be such commercial success. What was once the exotic space of daredevils is now the routine space that ferries our families.
It is not surprising then, considering the potential risks, to ask why a similarly dedicated system does not exist for nuclear material transports. In rating risks, we consider direct use material\textsuperscript{1} to have the highest risk.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Hourly Snapshot of All Active Flights, May 20, 2009, 1400 hours\textsuperscript{5}}
\end{figure}

In the United States, there are currently 104 operating nuclear power plants, as well as a considerable number of research reactors and other nuclear facilities operated by the USDOE National Laboratory complex. Even though spent nuclear fuel is safely stored at these facilities, within the next one to two decades, it is expected to be transferred to regionally located temporary storage centers and possibly to a national spent fuel repository. Current estimates are that there will be hundreds of such transfers of nuclear spent fuel in transfer casks from nuclear power plants to such repositories. Currently, HEU is being mixed with low enriched uranium and is being down-blended at facilities in Lynchburg, Savannah River, Oak Ridge and Portsmouth\textsuperscript{6}. The National Tracking Center could monitor transfers of HEU that are sent to these facilities for down-blending. In addition, the new Mixed Oxide (MOX) Fuel Fabrication Facility at the DOE Savannah River Site (SRS) is scheduled to begin operation circa 2016. This facility will produce fresh MOX fuel assemblies, which will be transferred to nuclear power plants licensed to handle such fuel\textsuperscript{7}. The current GPS tracking devices that have been developed both commercially and by the USDOE National Laboratories could monitor these shipments in real time and permit

\textsuperscript{1} IAEA Safeguards Glossary, 1980: Direct-use material – nuclear material that can be converted into nuclear explosive components without transmutation or further enrichment, as for instance plutonium containing less than 80% plutonium-238, HEU, and uranium 233.
effective tracking and response. If shipments were stopped due to highway accidents, inclement weather, or other events, the status of the delay would be noted in real time, along with other relevant data for the cargo – including possible external radiation, chemical indicators, elevated temperatures and excessive shock (due to collision). Considering the size of the United States, there should be at least two regional tracking centers in order to afford a level of redundancy. One could be based in the western United States, perhaps at the USDOE Idaho National Laboratory (INL), in the state of Idaho, and the other could be based in the eastern United States, perhaps at the DOE Oak Ridge National Laboratory (ORNL), in the state of Tennessee. This would allow regional and overlapping coverage for monitoring the shipments of direct-use material. The National Tracking Centers would be designed and constructed in the manner of the United States NASA Mission Control Center in Houston, Texas. They would be capable of receiving hundreds of real time data feeds regarding the shipment, location, and status of direct-use nuclear materials being transferred within the United States. These data feeds would be suitably encrypted and transmitted across available internet or satellite band-widths. The data feeds would be decrypted at the Tracking Center and logged into the data servers and archival database. The relevant data would be displayed on a number of manned monitoring stations, showing the real time geographical location, progress along the planned route, and status of the cargo. There would also be screens to highlight alarm conditions that indicate if any of the shipments experience delays and/or changes in routing, excessive shock, changes in expected radiation signal, chemical indicators or elevated temperature, due to a highway collision or other reasons. This information would also be essential for interfacing with local fire, police, and hazardous materials departments to ensure they recognize the special nature and hazards of the material being shipped – especially if transport involves an accident or attack.

We envision that a National Tracking Center will be essential in countries with large numbers of nuclear facilities, and where shipments of direct-use nuclear materials are becoming more common, such as in the United States, Japan, the United Kingdom, France, China, India, and Russia. We also envision that a National Tracking Center could ultimately establish the foundation for building an International Spent Fuel Tracking Center for monitoring the shipments of nuclear direct-use material worldwide. Considering that international nuclear material security and safeguards is the purview of the International Atomic Energy Agency (IAEA), it seems logical to propose that this center be based at IAEA Headquarters in Vienna, Austria, as well as at the regional offices in Tokyo and Toronto.

With the Nuclear Renaissance and the expanded use and transfer of direct-use nuclear materials (HEU, MOX, spent nuclear fuel) and large sources used in industrial applications, more effective tracking of such shipments in real time is now technically possible and could be monitored at a National Tracking Center. This would help guarantee that the transfer and shipment of such materials is fully safeguarded and that a rapid response to any unexpected event can be initiated.

Technology
There has been nothing short of a revolution in the use of GPS tracking technology worldwide. Concepts such as just-in-time, routing flexibility, and reduced losses and risk, have resulted in a massive infusion of funds by industry into this technology to reduce costs and improve service to maintain a competitive edge. Such modern vehicle tracking systems typically measure and record longitude, latitude, vehicle routes, stops, mileage, speed, trip time, and idle time. All of these are overlaid on detailed surface maps.

In addition to the existing commercial technologies, we believe that, due to the high value and sensitive nature of the items to be tracked by a dedicated National Tracking Center, additional functionality is warranted8. This includes sensors on the cargo that detect appropriate attributes
of the items being shipped, either in a normal safe mode or in a breach mode. For example, this could include small low power solid state gamma and/or neutron detectors, cameras, accelerometers, chemical, shock, humidity, and temperature sensors, and RFID tags. Off-normal conditions would trigger an alarm, as when a radiation sensor fails to detect the expected gamma or neutron signal or if a chemical sensor detects fluoride, indicating a potential breach in a UF₆ cylinder. Additions to the tracking technology would include alarms triggered by unplanned route changes and time-based alarms triggered when set route durations are exceeded.

**Tracking Center**

The concept a tracking center for valuable items is by no means new. The National Nuclear Security Administrations Office of Secure Transportation (OST) was established to safely and securely transport nuclear weapons, weapons components, and special nuclear material (SNM) to meet projected NNSA, Department of Defense, and other customer requirements. These shipments are highly guarded for the protection of the public and US national security. OST maintains a nationwide communication system that monitors shipment status and location, and maintains real time communication 24 hours a day, 365 days a year. OST also maintains an emergency contact directory of federal and state response organizations located throughout the contiguous United States. Nevertheless, it is not our intent to use this as a comprehensive model, due to the unusual nature of their items and classified nature of the program. A complementary system is the DOE TRANSCOM tracking and communications system that covers all other unclassified “high visibility” shipments by DOE. This system combines satellite and ground-based communications to monitor the progress of DOE truck, rail, barge, and ocean vessel shipments in near real time. In the commercial world (there are many companies available) one example of such a tracking service is provided by Qualcomm under the tradmarked product names of: Omnivision & OmniTRACS. Figure 2 shows both the GPS dome and operator console. All of these systems show a similar application for the protection of valuable and potentially dangerous items and they are mature, functioning system. All show that the fundamental technology foundation for a National Tracking System already exists.

![Figure 2 OmniTRACS vehicle based system](image)

It is expected that a National Tracking Center would be manned continuously. With the expected number of shipments, it is also clear that many of its features would have to be automated to allow for efficient tracking and effective responses. As with OST and TRANSCOM, an emergency contact directory for all necessary transportation pathways response capability would have to be maintained. This would address not only a police-type response but both fire, ambulance, and hazardous materials capability as well, with pertinent information provided (real...
time) to response support organizations. Additionally, because of the unique nature of the potential hazards, capability to deal with these hazards along the route must be assured.

An International Tracking Centre would improve domestic and international nuclear safeguards, because it would allow safeguards inspectors to monitor declared shipments of HEU, Pu-MOX and spent nuclear fuel before and during shipment, and at the point of being received. Because of its need for independence, the IAEA has other constraints in using information from such a system. Normally the IAEA employs tamper indicating devices and other authentication approaches to assure data integrity. However, in cases where this may not be practical or possible, the IAEA does use what is termed as “operator data” to some degree as an indicator of activity. In this case, an alternate approach can be used to validate this information. Because the IAEA cannot, for example, quantify every item in a large nuclear facility, it uses a statistical sampling approach to validate an inventory at a defined confidence level. A similar sampling approach can be used employing the short notice random inspection approach on individual shipments or receipts at nuclear facilities; thereby validating the accuracy of the systems information. Since the provider of the information does not know which transport will be validated or when it will be validated, this provides the necessary level of uncertainty to a potential adversary to not risk modification of shipping activities or the items being shipped.

Conclusion

The authors believe that with the rapid expansion of the nuclear fuel cycle and the obligations of the United States to protect its citizens and the environment in a reasonable, effective, and efficient manner, the creation of a National (and International) Tracking Center is an integral part to provide State-based and global security for the Nuclear Renaissance. Most of the relevant technologies are already commercialized; modest expansions of these technologies are needed to produce focused, robust, and reliable systems. Such a Center(s) would be a firm demonstration of commitment to nonproliferation and it would be in the best interest of the world. We believe that this is not a situation that can wait for a catastrophic event. The negative repercussions of such an event could seriously damage the future of the Nuclear Renaissance. It is time to act now.
REFERENCES


