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1. INTRODUCTION

The U.S. Department of Energy (DOE) Transportation Management Division (TMD) has developed a system which allows communications with and near real-time tracking of high-visibility shipments of hazardous materials. This system, which is known as TRANSCOM (Transportation Tracking and Communications System), is currently in operation, and its use for certain shipments is mandated by DOE Order 5632.11, Physical Protection of Unclassified Irradiated Reactor Fuel in Transit, September 15, 1992, and in a draft DOE Order 1540.28, which is expected to be issued shortly. Specifically, Order 5632.11 states:

> "To achieve the objectives of this Order, a physical protection system shall be established and maintained to include:
>
> a. All shipments of DOE unclassified irradiated reactor fuel will utilize the DOE Transportation Communications System (TRANSCOM) for communications between the transport vehicle, TRANSCOM control center, and the responsible field element/contractor Emergency Operations center.
>
> b. A Carrier's communications center at a designated location which will be staffed continuously by at least one individual who will monitor the progress of the irradiated reactor fuel shipment and will notify DOE and other appropriate agencies if an emergency should arise."

This paper summarizes the current status of TRANSCOM, its history, the experience associated with its use, and the future plans for its growth and enhancement. During the first half of fiscal year (FY) 1994, 38 shipments were tracked by the TRANSCOM system. These shipments included two Mark-42 spent fuel shipments, one BUSS cask shipment, and one waterway shipment (the *Seawolf* shipment).

2. BACKGROUND

The TRANSCOM system is comprised of satellite communications, data-base management, computer networks, and a commercial telecommunications service, which are used by vehicle operators, carriers, shippers, and receivers and federal, state and tribal government agencies to monitor the movements of waste shipments, and by carriers, shippers, receivers and DOE who use the system to communicate with a vehicle.

The system, whose operation is sponsored by DOE's TMD, is run from the TRANSCOM Control Center (TCC), which is located in Oak Ridge, Tennessee. The TCC, which was established in 1988, houses the UNIX-based computer network, which stores information about each shipment on a central data base and controls all communications. Access to the system is simple for users because it requires only the appropriate software package (including user manual and other documentation), a confidential user ID and password established during training, a standard telephone line, an IBM-compatible personal computer, and a 2400-baud Hayes-compatible modem.

Vehicles carrying high-visibility materials requiring communication and tracking capability (including spent nuclear fuel) are equipped with Omni-TRACS mobile communications terminals, which are made by QUALCOMM. Periodically, a request for a positional update is issued by the TRANSCOM Unix computer. The time between positional updates can be controlled at the TCC and varies from as little as 1 min up to 9999 min. For most shipments, updates are collected every 15–30 min. It takes approximately 1 min to receive the update information through the QUALCOMM system. At the same time the update information is being gathered, any messages to or from the vehicle operators are transferred. Messages may be sent to the vehicle operators only during a positional update. Hence, when the TRANSCOM system shows that the vehicle is experiencing nonnormal operating conditions or when the vehicle is traversing a particularly hazardous section of roadways, the time period between positional updates is reduced by the TRANSCOM operators. Messages between the TCC, shippers, receivers, and other users are controlled by the TRANSCOM Unix computer and may be transmitted at any time.

TRANSCOM is used to track a number of different shipments. Some of the most highly visible shipments include the following.

- Spent nuclear fuel
- Cesium capsules
- Uranium hexafluoride
- Three Mile Island waste
- Waste Isolation Pilot Plant Demonstration shipments
- Transportation emergency response exercises and drills
- Pathfinder decommissioned reactor vessel—rail shipment
- *Seawolf* submarine components—water shipment

The Pathfinder and *Seawolf* shipments were unique in that the transponder on each shipment was powered using solar panels. The Pathfinder shipment was a rail shipment of a decommissioned reactor vessel. The shipment was tracked from Sioux Falls, South Dakota, to Richland, Washington. The vessel was transported by Burlington Northern Railroad, August 7–12, 1991. The solar power unit was designed to supply power to operate the transponder. Backup batteries were used to supply power sufficient to operate the transponder for 4 days without any charge from the solar panels in

the event of inclement weather. TRANSCOM successfully tracked the Pathfinder shipment by using the solar panels to operate the transponder.

The *Seawolf* shipment was a barge shipment of submarine components that was tracked from Oak Ridge, Tennessee, to Groton, Connecticut, November 14–December 2, 1993. The barge traveled the Tennessee River, to the Tennessee/Tombigbee waterway, to the Tombigbee River until it reached the Gulf of Mexico. It then traveled around the western side and the tip of Florida and proceeded up the eastern seaboard to Groton, Connecticut. A solar power unit was used to supply power to the transponder; however, the shipment took place during an extended period of cloudy weather. Because the inclement weather caused limited solar input, the battery power weakened. This weakening resulted in a loss of the transponder signal for three nights. Fully charged backup batteries were installed at Florence, Alabama, to correct this problem. The new batteries, together with the improving weather, provided sufficient power to the transponder to successfully track the shipment during the remaining 15 days of the trip.

3. SYSTEM DESCRIPTION

On the TRANSCOM display screen, the position of the vehicle being tracked is shown by an icon on a map. Over 3100 maps are included in the TRANSCOM system. The icon is color-coded (green, yellow, magenta, or red) to show the status of the vehicle. A shipment that is proceeding normally is shown with a green icon. A yellow icon is used to indicate that there is some minor problem, such as a mechanical breakdown, flat tire, etc. A magenta icon is used if there is a more serious problem, but a problem that does not affect safety. If the vehicle is involved in an accident or in other emergency situations, a red icon is displayed.

The icons can be displayed on a series of computer-generated maps. Three levels of geographic detail are available to the user: the entire United States, an individual state, or an individual county. The user can opt to select any of the maps and also has the ability to superimpose the highway and/or rail network upon the map area selected.

TRANSCOM provides TCC, DOE, shippers, and interested governmental bodies with the capability of monitoring the shipment's location to within 1000 ft; provides the TCC and shipper with the ability to communicate with each other; and provides a nationwide communication link with the vehicle. This latter capability allows the TCC to transmit weather information to the vehicle operator via the carrier, and the vehicle operator to transmit information on the status of the movement of the vehicle, when it is stopping, why it is stopping, etc. Information is available, depending on the access level of the user, in various forms, including:

Vehicle location,
Shipment status,
Shipment characteristics,
Bill of lading,
Emergency response information,
Advance notification information,
Report (a comprehensive listing of shipments in transit), and
Two-way messaging.

Four levels of user interactions are currently provided in the TRANSCOM software:

1. The TCC has full functionality for all shipments,
2. Carriers, shippers, and receivers have all functions for shipments in which they are involved,
3. DOE's Emergency Response Centers have view-only functions for all shipments, and
4. States and Indian tribes have view-only functions for shipments traveling through their jurisdictions.

Normally, the TCC is manned during normal working hours, 5 days a week, 8:00 a.m.–5:00 p.m., Eastern Time. However, when shipments being tracked by TRANSCOM are in transit, the TCC is manned 24 hours a day.

While the TRANSCOM system was not designed as an emergency response system, the TCC is frequently the office in the DOE chain to be aware of a non-normal condition. When such a condition is noticed, the TRANSCOM operator will immediately notify the appropriate DOE Emergency Control Center, which will in turn notify the first responders. During an emergency, it is envisioned that TRANSCOM will be a clearing house for information. For example, a responder in the field might contact the TCC for information noting the response procedure for a spill of hazardous material. The TRANSCOM system contains information from the *U. S. Department of Transportation Emergency Response Guidebook* pertaining to the materials transported in each shipment. The TCC generates a hard copy of the needed material and forwards the information to the responder.

TRANSCOM was used during FY 1993 to track almost 100 shipments within the DOE complex, and it is accessed weekly by 10 to 20 users. During FY 1993, both the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission were trained to use the system and since have become active users.

Future activities for TRANSCOM include a new enhanced graphics system which will replace the display system currently being used. The enhancement will be based on a graphics system being developed for the HIGHWAY and INTERLINE routing models, which is based on TIGER data. This new system will provide a more accurate representation of the transportation networks and enhanced graphics at both the TCC and remote user sites. Rather than displaying an excessive amount of unnecessary data on the map, the new system will provide enhanced readability by simplifying data presented on the screens for tracking shipments. Point and query capabilities will be included which will allow the users to determine the name of a highway and the distance from the nearest node (highway intersection) found in the HIGHWAY data base. All other TRANSCOM capabilities, such as the ability to obtain information about bills of lading, emergency response, etc. will be preserved when the enhanced graphics are integrated with the current system.

4. SUMMARY

The TRANSCOM system has demonstrated its capability to provide reliable tracking and communication between a vehicle and other users monitoring high-visibility DOE shipments. The nearly 100 shipments tracked within the DOE complex during FY 1993 and the number of users regularly accessing the system will most likely continue to grow as interest in system use continues to expand into new areas and to include a greater variety of organizations. With this growing interest and increasing tracking requirements, the TRANSCOM system will also be upgraded.