SATELLITE TRACKING OF RADIOACTIVE SHIPMENTS--

HIGH TECHNOLOGY SOLUTION TO TOUGH INSTITUTIONAL PROBLEMS

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ABSTRACT

Three troublesome institutional issues face every large-quantity radioactive materials shipment:

- Routing: Where's the shipment going and how's it getting there?
- Pre-notification: States want to know what's being shipped and when?
- Emergency Response: What kind of response to accidents is needed for this shipment and who'll respond?

The Transportation Communications System (TRANSCOM), under development by DOE, is based on a rapidly developing technology to determine geographical location using geo-positioning satellite systems. This technology will be used to track unclassified radioactive materials shipments in real-time. It puts those charged with monitoring transportation status on top of every shipment. Besides its practical benefits in the areas of logistics planning and execution, it demonstrates emergency preparedness has indeed been considered and close monitoring is possible. This paper will describe TRANSCOM in its technical detail and DOE plans and policy for its implementation. The state of satellite positioning technology and its business future will also be discussed.

BACKGROUND

The Atomic Energy Act, Hazardous Materials Transportation Act, and the Nuclear Waste Policy Act (NWPA) require the Department of Energy (DOE) to provide for the safe, secure, and efficient transportation of radioactive materials. The DOE, in carrying out these requirements, needs to monitor shipments of nuclear material in support of emergency response and other activities.

Recent experience in major shipping campaigns has shown increasing concerns on the part of state and local governments over radioactive material shipments moving through their jurisdictions. The concerns will become even more intense when transuranic wastes begin moving to the WIPP site and commercial spent fuel is shipped in volume for either monitored retrievable or repository storage.

The states have expressed the need for obtaining more information on radioactive material shipments to improve their ability to prepare for and respond to various transportation contingencies. In particular, they want to know the exact date and time that each radioactive shipment will enter their state and the precise route it will follow in order to be fully prepared for an emergency.

Partly because of the relative lack of such information, many State and local governments have enacted laws and ordinances banning or restricting shipments of radioactive materials through their jurisdictions. The resulting patchwork of laws and ordinances places conflicting and route-restricting demands on DOE whose primary task is to safely transport radioactive materials from origin to destination in the most direct and efficient manner. Three transportation issues at the top of DOE's need-to-solve list are prenotification, routing and emergency response.

TRANSPORTATION COMMUNICATION SYSTEM--TRANSCOM

DOE has developed a prototype transportation tracking, communication, and information management system (TRANSCOM) that will enhance DOE's oversight and response capability as well as respond to state and local concerns. TRANSCOM combines a data base management system with communications technology which will provide DOE headquarters and field offices with instant information about the location and status of their shipments. For the first time in the Department's history, Headquarters, the eight DOE Operations Offices, and their contract carriers, as well as key state and local officials, will be linked together in near real-time by a system to share information.

IMMEDIATE ACCESS TO CRITICAL INFORMATION

The system will provide a real-time map location as well as detailed bill of lading and routing information on all shipments. Access to this information significantly enhances emergency preparedness posture for both DOE and state and local officials. It also allows DOE to improve the dispatching and efficient use of its packaging fleet.

Vehicle Location

The TRANSCOM system uses advanced technology to track the location and status of DOE's unclassified nuclear shipments. This technology will make use of satellites to determine the latitude and longitude coordinates of shipments. Satellites will also serve as two-way communication links between the vehicle and the shipper.

Tracking the location and status of nuclear shipments is the central purpose of TRANSCOM. The scope of the tracking capability is the continental United States. A map of the 48 states projected on a computer

monitor uses color-coded icons to provide a general overview of all shipments underway. The TRANSCOM user will also be able to view separate screens. A map of the U.S. railway system displays on-going DOE rail shipments, and a map of the U.S. highway system displays truck shipments. The tracking function will be able to zoom in on three levels of maps: U.S., state, and county. Interstates, state level roads, and major rail links will be identified.

Bill of Lading Information

Data will be entered to provide designated officials with information about current and upcoming nuclear shipments. For each planned shipment, specific data such as the schedule, planned routes, and type of radioactive material will be available. All the information carried on the truck or rail manifest and required by DOT regulations will be available.

DOT Emergency Response Procedures

DOE users will be able to select emergency response information from the Department of Transportation (DOT) Guidebook for Hazardous Materials Incidents (1984). The scope of this file includes all the regulatory categories of nuclear materials that can be expected to be shipped in highway-route-controlled quantities. DOE or states can use this function in an accident to quickly determine what response measures are needed for the shipment in question.

Federal/State Points of Contact

The emergency information includes the key emergency response contacts at DOE Headquarters, the originating field office, and the shipper. The contacts for the state and the field office closest to the accident will also be shown.

READILY-AVAILABLE HARDWARE

The TRANSCOM system will support a fully-implemented system with many remote users. DOE HQ will operate and maintain the TRANSCOM central computer. The central computer receives the shipment location information from the GEOSTAR ground station and maintains and updates the principal TRANSCOM database. The remote user computers can access the central computer via telephone lines to obtain current information concerning shipment locations, bills of lading and emergency response data.

Transceiver

Each identified shipment would have a GEOSTAR LINK ONE transceiver which will automatically calculate and send location information to the satellite every 15 minutes. This data will be used to automatically track the progress of the shipments on the display maps. Alternatively, or for back-up purposes, a driver can enter data as he passes specific checkpoints. The driver will be given computer-generated checkpoint lists at the originating facility for his preapproved route and for any preapproved alternate routes. These checkpoint lists will include the route and descriptions of each of the checkpoints, including the checkpoint number and a description of the highway intersection or state border crossing corresponding to it. The driver uses the keyboard on the transceiver to enter the number of the checkpoint and presses the enter key when he passes a designated checkpoint. If the signal has been transmitted, the on-board system will indicate a successful transmission. If the driver does not receive this kind of message, he will immediately phone his dispatcher. His dispatcher can then track the shipment manually. The same prodecure could be used if the driver must use an alternate route which has not been preapproved.

Microcomputer Configurations

The TRANSCOM central computer is designed to handle multi-tasking and multi-user operations. It must be a relatively well-equipped, high-speed microcomputer such as an IBM PC/AT or compatible. In the fully-implemented system, the AT will be linked to up to six slave PCs. Each slave PC will have a multiport serial communications board for BELL-212 data transmission protocol along with a set of four Hayes compatible smart modems of 1200 baud rate capability for supporting remote users.

The remote user terminals are single user computers such as an IBM PC/XT or compatible equipped with a 20-megabyte internal fixed disk for using the TRANSCOM database and an enhanced color graphics monitor for map displays. In addition, each XT will be equipped with an internal 1200 baud Hayes compatible smart modem for communicating with the central computer. Each remote user's system will have already stored the mapping file to improve system response time.

Data Security

Although the information in TRANSCOM is not classified, the information will be protected through the following design features:

- o user passwords;
- o unique transmitter identification codes;
- o spread spectrum LINK ONE bursts;
- o dedicated phone line from GEOSTAR to TRANSCOM central; and,
- o system encryption devices, if necessary.

GEOSTAR SATTELITE

The GEOSTAR System, proposed as the world's first commercial "Radio Determination Satellite Service", will provide a unique, patented means of nationwide two-way communications. Messages will travel in complete privacy, encrypted if necessary, directly through satellites in a matter of seconds.

Based on the GEOSTAR's potential for saving lives, reducing crime and increasing the efficiency of American industry, a formal proposal was published in 1984 by the Federal Communications Commission to allocate the special radio frequencies needed for the new "Radio Determination Satellite Service."

The GEOSTAR satellites will be in "stationary" orbit, at fixed points 23,000 miles above the continental U.S. A computer at GEOSTAR central will transmit general interrogation signals to each transceiver through satellite relays, many times per second. Each transceiver will be identified by a unique "fingerprint". A digital code built in at the factory, will identify the messages it sends and select the messages addressed to it.

The GEOSTAR System will measure the location of each transceiver by combining the time of interrogation, the times at which the response is received through two satellites, and stored digital information on local terrain heights. That location will not be revealed to anyone without authorized access. No one can use the tranceiver without first

keying a private code. Complete confidentiality of information is assured.

Because the required number of satellites for determining latitude and logitude is not yet available, TRANSCOM is being configured at two levels: as a one-way identification system for the near term, and as a two-way communications system for the long term (late 1980's when the satellite links will be available).

Near-Term System

Figure 1 illustrates the configuration of the TRANSCOM prototype system which will be tested at DOE HQ and three field offices. The prototype is based on currently available technology and can be implemented as soon as the first GEOSTAR satellite is launched. A ground-based, low-frequency navigational system known as LORAN-C determines the latitude and longitude of the position of the shipments to within 1/2 mile. The LORAN-C box carried on the vehicle calculates the position of the vehicle on the basis of signals emitted from the nationwide system of LORAN-C towers. Latitude, longitude, status, shipment identification, and optional text messages are transmitted periodically to a GEOSTAR communications satellite. GEOSTAR relays the information to its ground station near Princeton, NJ, from where it is sent to DOE. A driver-initiated status indication can also be transmitted via GEOSTAR to the central computer.

Longer-term System

Figure 2 depicts the final full-scale TRANSCOM system. This system will be used by DOE, and other Federal agencies. As Fig. 2 indicates, the communications link from the vehicle to the TRANSCOM central computer is the same as is used in the prototype. The full-scale system differs from the prototype--latitude and longitude position of the shipment will be computed more precisely on the basis of satellite signals with an overall accuracy of 5 meters. The GEOSTAR satellite positioning system is expected to be fully operational in the late 1980's. The TRANSCOM prototype is designed so that the improved position location accuracy can readily be integrated into the system with little or no disruption. In the full-scale system, there is an automated status indicator which is supplementary to the driver-initiated status. In addition, this version will have expanded emergency response capability, including automated DOE procedures and checklists.

IMPLEMENTATION PLAN

To date, the TRANSCOM system requirements have been defined, and first generation software has been completed. The TRANSCOM software was developed by Systems Research and Applications Corporation (SRA) and was formally demonstrated to DOE in January, 1987.

The satellite service to be used in the near-term system (LINK ONE) is expected to be offered by Geostar Corporation in September 1987. This date is predicated on a successful satellite launch. Phase over to the longer term satellite system is dependent on subsequent satellite launches, and will be implemented as soon as the two-way communication service is available.

When the initial testing phase is complete and necessary revisions have been incorporated and tested, the system will be made available to all DOE field offices and shippers, and then to state designees.

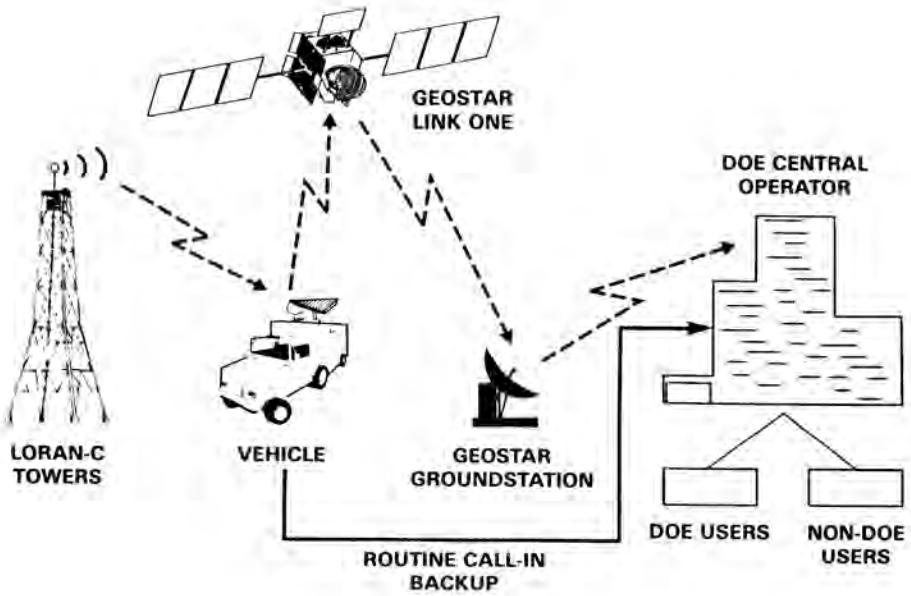

Fig. 1. GEOSTAR LINK ONE Service.

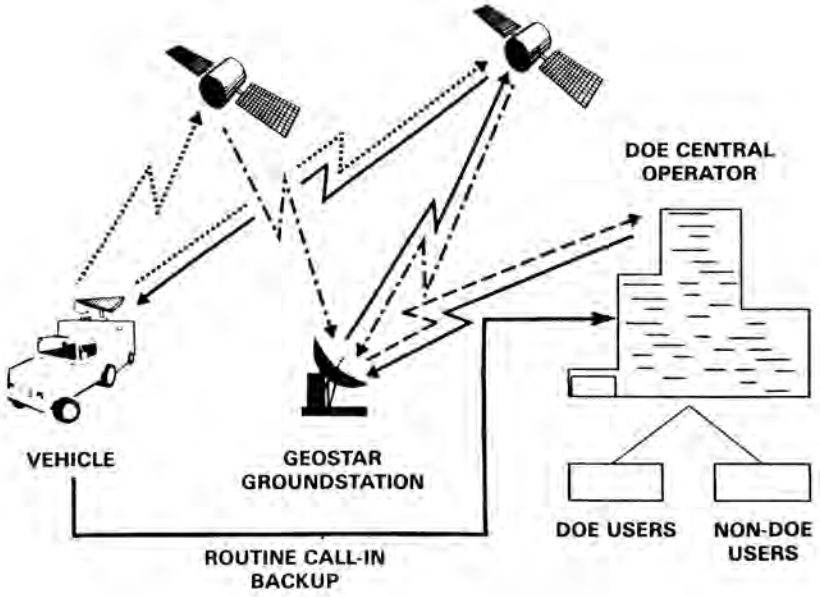

Fig. 2. GEOSTAR Prime Service.

SOFTWARE OUTPUT

Each en route shipment which is being tracked by satellite or by carrier call-ins, will be displayed on the map with its corresponding transmitter number. The user has the option to zoom in on a particular state and then to a particular county. All shipments in the lading file which have left their point of origin but have not arrived at their destination will be tracked on the map.

When the tracking function is chosen from the main menu, the user has the choice of viewing all shipments, motor or rail for all of DOE, or motor or rail for a particular field office appears. The all-shipment option enables the user to view a map of the U.S. with the states designated, but without rail or road markings. This map displays all on-going shipments, regardless of whether they are rail or motor shipments. Each shipment will be designated as rail or motor by the shape of the icon. The shipments's status is indicated by color. In addition to the country-wide overview, the user has the option of viewing just rail or just motor shipments for a particular field office or viewing rail or motor for all DOE shipments. DOE Headquarters will always view all on-going shipments for either rail or motor.

The rail maps display all major rail lines for the U.S., states, or counties. The motor maps of the U.S. and the states display all major U.S. interstate and state highway routes. In addition, the U.S. maps show state names and major city names. The state maps show major city names and county names. The county maps show major city names. At each level of the mapping function, the user may choose to investigate the lading information for a particular shipment.

DOE personnel responsible for nuclear shipments will require access to detailed information about each shipment. The lading information file provides this information; it includes all the data elements required by 49 CFR 172 and 173, including a listing of all radioisotopes by name and their total activity level. The purpose of this file is to provide a readily-accessible, detailed source of information about the kind of material being transported. The shipment identification code displayed on the tracking map provides the link between the tracking function and the lading file.

Choosing the checklist option from the main menu will place the user in a second menu from which he will be able to execute a checklist in case of an emergency. The user will be prompted for a shipment number, which will be used to locate the emergency contact information for this shipment. The user will then be presented with a menu of hazardous materials. After the user selects the appropriate material, he will be presented with several screens which contain all emergency contact information and recommended emergency procedures.

SUMMARY

DOE's mandate to ship radioactive materials safely and efficiently has been affected by institutional issues arising from serious state and local concerns. These concerns result from the local officials' view that a lack of information prevents them from being on top of the situation and responding to emergencies.

The TRANSCOM system offers a cost-effective solution to DOE's shipment tracking requirement. It enables DOE HQ and field office users to share information in near real time. If the system is made available to a state or local government, it would provide required prenotification and routing information. The precise time of arrival at a given border can be accurately estimated by monitoring the progress of the shipment as the system tracks its location. Built-in emergency response guidelines will prompt state and local as well as Federal officials with the proper procedures if there's an accident. In short, this high-technology, real-time tracking system solves major institutional as well as operational shipping problems.