ORNL IntelligentFreight Initiative: Enhanced End-to-End Supply Chain Visibility of Security Sensitive Hazardous Materials

(Focus on Radioactive Materials "Quantities of Concern" Use Case)
Concept Paper ORNL/TM-2009/054

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Executive Summary

In the post September 11, 2001 (9/11) world the federal government has increased its focus on the manufacturing, distributing, warehousing, and transporting of hazardous materials. In 2002, Congress mandated that the Transportation Security Agency (TSA) designate a subset of hazardous materials that could pose a threat to the American public when transported in sufficiently large quantities. This subset of hazardous materials, which could be weaponized or subjected to a nefarious terrorist act, was designated as Security Sensitive Hazardous Materials (SSHM). Radioactive materials (RAM) were of special concern because actionable intelligence had revealed that Al Qaeda desired to develop a homemade nuclear device or a dirty bomb to use against the United States (US) or its allies.[1]

Because of this clear and present danger, it is today a national priority to develop and deploy technologies that will provide for visibility and real-time exception notification of SSHM and Radioactive Materials "in Quantities of Concern" (RAMQC) in international commerce.

Over the past eight years Oak Ridge National Laboratory (ORNL) has been developing, implementing, and deploying sensor-based technologies to enhance supply chain visibility. ORNL's research into creating a model for shipments, known as IntelligentFreight, has investigated sensors and sensor integration methods at numerous testbeds throughout the national supply chain. As a result of our research, ORNL believes that most of the information needed by supply chain partners to provide shipment visibility and exceptions-based reporting already exists but is trapped in numerous proprietary or agency-centric databases.

ORNL's IntelligentFreight solution is based on two components:

- A Web 2.0 enabled portal with "security enhanced social media" capabilities to connect the various supply chain stakeholders with each other and to assign a dynamic and persistent identity (encoded as a unique web address or Uniform Resource Locator (URL)[2]) on the fly. This takes on the role of a permanent and unique *Virtual Resource Identifier (VRI)*[3].
- The ability to dynamically incorporate and associate searchable user-defined tags to the Virtual Resource Identifier. These tags are contributed incrementally by the various stakeholders involved in the progress of the shipment, but they do not interfere with the seamless operation of the whole system.

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[1] On August 16, 2007, José Padilla was found guilty, by a federal jury, of charges against him that he conspired to kill people in an overseas jihad and to fund and support overseas terrorism. He was widely described in media as a suspect of planning to build and explode a "dirty bomb" in the United States, but he was not convicted on this charge.

[2] In Information Technology applications a URL is a type of Uniform Resource Identifier (URI) that specifies where an identified resource is available and the mechanism for retrieving it. It is more popularly called a web address.

[3] A virtual resource identifier is a uniquely assigned string that remains with an item and/or shipment forever (i.e., also past the lifetime of a shipment).

By allowing an identifier to be created dynamically, the system becomes agnostic to origin – by region, by sector, by mode, by owner, and by regulation. By allowing growing tag associations with the shipment, the system becomes resilient and flexible to transfers between carriers and institutions, and at the same time can tolerate incorrect, partial, or faulty information. The searchable association allows all steps in the supply chain to "get to what they want" for identification and visibility purposes. This methodology is aimed specifically at minimizing any disruption or reconfiguration in existing commercial supply chain tracking systems, databases, and deployed sensors. A unique combination of proliferating data-sharing technologies coupled with simple bridges to legacy systems offers deep RAMQC visibility, minimal process disruption, and a viable path to adoption.

Web 2.0

There is no rigid agreement on what Web 2.0 is. Tim O'Reilly's original definition opines "Web 2.0 as the recent Web innovations that have facilitated "communication, information sharing, interoperability, and collaboration." Typically, these Web innovations are thought of as social-networking sites, video-sharing sites, wikis, and blogs. The ORNL Sensorpedia project defines Web 2.0 innovations as follows "The emergence of social media signifies a major democratization of the way we get and share information. As recently as the mid 90's, most information was delivered by traditional media (i.e., the video and audio broadcast networks and printed media). Access to these channels was limited to enterprises that could afford the expense of sharing information. Apart from the "letters to the editor" page or the "call back" number at radio stations, information flowed one way. Although the traditional media still is the primary means of broadcasting information, the Web, more than any other modern technology, has opened information sharing to many, many more participants who have the bare minimum tools— a desktop, laptop, or mobile phone and an Internet connection."

RAMQC and SSHM supply chain visibility can be achieved with the above emerging information sharing mechanisms in an efficient and effective manner, with minimal impact on existing operations and proprietary process networks, and at low operational cost. Furthermore, the IntelligentFreight technical prototype will satisfy RAMQC supply chain needs for visibility, security, exception reporting, and cost effectiveness, the prototype can be used to track all other SSHM in the supply chain using the same methods and tools.

This approach offers a viable alternative to waiting for the optimistic, but unrealistic solution that expects all sectors to agree a priori. The ORNL approach is driven by commercial and regulatory supply chain concerns and scales regionally as well as by shipment sectors and transportation modes.

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The National Need

It is a national priority to enhance the identification, tracking, and monitoring of all RAM shipments, as well as the identification and interdiction of illicit materials, in international commerce using air, rail, shipping, and inter-modal infrastructures.

At issue is the balancing of hazardous materials (hazmat) transportation security and safety with the ability to continue to move goods that are critical to public health, commerce, and the economy. In the wake of the 9/11 terrorist attacks, the chemical and transportation industries, Congress, and the media have focused increased attention on hazardous materials transportation security. Annually, there are an estimated 10 million shipments[4] of Department of Transportation (DOT) regulated hazmat in-transit in the US supply chain. Most of these hazmat shipments are part of an international product lifecycle. The successful use of these materials is dependent on the ability of the international supply chain to have them where they are supposed be on time, intact and within their shelf life. RAM makes up approximately 3 million of the annual hazmat shipments. RAM shipments are usually time-sensitive and shelf-life dependent. Their value is the ability of an end-user to have the material at a defined time and in a defined place. RAM product development and product lifecycle are nearly always global endeavors.

Soon after 9/11, Congress mandated that the DOT's Transportation Security Agency (TSA)[5] issue a comprehensive transportation security rule, HM-232, which required shippers of hazardous materials to take specific security measures. HM-232 also required TSA to identify a list of Security Sensitive Hazardous Materials (SSHM) that could be used to cause significant security risk when in transport. HM-232 further required TSA to establish a national tracking system for these materials. Two particular hazmat categories were considered of utmost concern to national security: Materials Toxic by Inhalation (TIH) and RAM, both of which could be used in a terrorist attack as a Weapon of Mass Destruction (WMD).

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[4] For the purposes of this concept paper the following definition of shipment is offered. The term "shipment" is synonymous with the terms cargo, consignment, car load, truck load etc. 49 CFR 173.403 defines a consignment as a package or group of packages or load of RAM offered by a person for transport in the same shipment. 49 CFR 171.8 defines a person to mean an individual, corporation, association, firm, partnership, society, joint stock company, or a government, Indian Tribe, or authority of a government or tribe offering a hazardous material for transportation in commerce or transporting a hazardous material to support a commercial enterprise. This term does not include the United States Postal Service or, for purposes of 49 USC 5123 and 5124 (Civil and Criminal Provisions), a department, agency, or instrumentality of the government. The term "Transport" is synonymous with shipment, transportation, logistics movement, carriage, etc. 49 CFR 171.8 defines transport or transportation as the movement of property and the loading, unloading, or storage incidental to that movement. The distinction between onsite and offsite transport is whether the public has unrestricted access to the transport conveyance or property or the operation of the conveyance in the public domain, i.e. public roads, waters, air space. The term includes carriage by for hire, contract, private and public operated conveyances.

[5] The TSA was later transferred to the Department of Homeland Security.

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Based on immediate and credible threats, TSA addressed SSHM (TIH) shipments by rail first. The final TSA rules addressed the rail transport of TIH and included requirements for the creation of a "chain of custody" tracking system to allow TSA to determine within minutes the location of rail cars carrying TIH materials. This rule also required that TIH supply chain stakeholders immediately report any potential threats and significant security concerns to the Department of Homeland Security (DHS).

The rail TIH commercial and regulatory sector tracking and monitoring system is an exemplary model of how to meet the post 9/11 Congressional Act mandate in a cooperative and comprehensive manner. However, this model only deals with one mode of transport where there are "captured" shippers and consignees and well-defined routes. This model is not scalable to intermodal, highway, or air express shipments of SSHM or RAMQC.

In August 2005, after study and national discussion, the Nuclear Regulatory Commission (NRC) issued the National Source Tracking System (NSTS) Rule codified in Title 10 Parts 20 and 32 of the Code of Federal Regulations (CFR). NSTS among other things established a list of twenty (20) radioisotopes defined as Nationally Tracked Sources (NTS)[6] and mandated security measures to be taken by NRC licensees during manufacture, storage, transport, receipt and disassembly. NSTS also required the manufacturers of Category 1 and Category 2 sealed sources[7] to establish a unique serial number for tracking purposes.

During 2008 the NRC sought public comment to revise NRC regulations establishing a "technical basis" for transportation security requirements of RAM *in quantities of concern* (RAMQC).[8] In February 2008 the Department of Energy (DOE) issued USDOE Notice 234.1 mandating RAM sealed source reporting requirements to its contractors. This departmental guidance mirrored the NSTS rule for NRC licensees and established a DOE Radioactive Sealed Source Tracking Registry.

The National Challenge

The common challenge of all RAM supply chain stakeholders, whether they are in the commercial or regulatory sectors, is the lack of real-time, end-to-end visibility of data throughout the supply chain.

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[6] A NTS is defined by NRC as a sealed source containing a quantity equal to or greater than Category 1 or Category 2 levels of any radioactive material listed in Appendix E to 10 CFR part 20.

[7] NRC has established a categorization of RAM based on safety and security concerns. The NRC categorization includes four categories with Category 1 being of highest concern and Category 4 being of lesser concern. The NRC taxonomy is based on individual isotopes and their quantity and is cumulative to a facility.

[8] RAMQC are defined as domestic and/or international NRC defined Category 1 – 4 sources and can be either Special Form or Normal Form sealed sources as defined by DOT. A DOT Electronic database exists for Special Form types of sealed sources.

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The US government regulatory sector[9] has a critical need for end-to-end "deep visibility" into the international multi-modal supply chain SSHM and RAMQC. The top-level federal requirements applicable to SSHM and RAMQC are spread among many agencies. All the agencies have some type of real time or position tracking or notification requirement.[10] Most agencies have their own tracking systems, notification procedures and emergency reporting centers. Currently, RAMQC, is only recognized by NRC, and there is no regulatory process for supply chain stakeholders[11] to differentiate between RAMQC and RAM in commerce. (Consequently, this Concept Paper focuses on a solution for tracking all RAM shipments in commerce.)[12]

Efforts to improve controls over RAM face significant challenges, particularly balancing the need to secure the materials without impeding their beneficial use in academic, medical, and industrial applications. RAMs are used in the oil and gas, electrical power, construction, and food industries. They are used to treat millions of patients each year in diagnostic and therapeutic procedures and are a critical component of a variety of military applications. Academic, government, and private institutions are all involved in RAM research and development. The uses and locations of these critical materials are diverse.

The RAM supply chain commercial sector[13] has developed post 9/11 security requirements in parallel with the aforementioned regulatory sector requirements. Organizations such as the Council on Radionuclides and Radiopharmaceuticals (CORAR), Radiopharmaceutical Shippers and Transporters Conference (RSCC), American Energy Service Companies (AESC), American Trucking Association (ATA) and the National Association of Chemical Distributors (NACD) have voluntarily enacted security guidelines for their membership.

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[9] The regulatory sector definition, for the purposes of this Concept Paper, encompasses any International, Federal, State or Local Government Agency who promulgates and/or enforces safety and security policy or regulations in the commercial sector of the SSHM supply chain.

[10] SSHM rules within other agencies include Department of Defense (DoD) – DoD 4140.1-R (Hazmat), Department of Health and Human Services (DHHS) - 42 CFR 72 & 73 (Etiologic/Select Agents & Toxins), and USDA – 9 CFR 121 (Select Agents or Toxins).

[11] For the purposes of this Concept Paper the definition of supply chain stakeholders will include, but not be limited to, international, domestic, state and local persons, entities or institutions who manufacture, fabricate, end-use, distribute, dispose of, recycle, transport, produce packaging , regulate, and enforce the law on hazmat, SSHM, RAM or RAMQC.

[12] As stated previously the DOT definition of shipment is used in this Concept Paper, however, for RAM tracking purposes government owned – government operated shipments that are not subject to the National Security Exemption or are exempted under 49 USC (Civil and Criminal Provisions) will be considered.

[13] Commercial sector for the purpose of this Concept Paper includes all SSHM supply chain partners who are in commerce.

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What Systems and Requirements Exist Today?

The Commercial Sector

Supply chain partners desire integrated end-to-end and access controlled tracking of SSHM and RAMQC with minimal impact on their existing (and often proprietary) enterprise tracking systems.

Commercial sector shipment tracking systems are critical business enterprise systems that are defined and bounded with fixed and predictable demands. Most have little modal integration (even within multi-modal companies), require strong centralized control, use proprietary shipment information exchanges, and lack exceptions-based reporting.[14] Current information exchanges between supply chain stakeholders are Electronic Data Interchange (EDI) based and driven by each enterprise's proprietary system. Several efforts are underway to standardize and automate the documentation exchange but to date no single solution has been universally adopted by commercial sector supply chain stakeholders.[15]

In some cases, the commercial sector's proprietary tracking systems use multi-sensor technologies that are integrated at the transporter level. Examples of tracking technologies used in proprietary tracking systems include:

- Barcode (Most common at the package level)
- Satellite (Most common at the power unit level)
- RFID (Most common at the transport equipment level)
- Cellular (Most common at the personnel level)

There is no automated shipment tracking system that reaches across the supply chain transporters during the life of a shipment. Better said, supply chain partners lose visibility when tracked shipments exit their system. EDI merely allows a smoother documentation handoff at a partner to partner level. The supply chain owner[16] has no visibility of the shipment as it moves between multiple transporters nor is there any universally adopted system in the commercial sector that provides this level of visibility.

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[14] Post economic deregulation has led to the consolidation of large multimodal carriers who have large legacy tracking systems that were built around their business case (i.e. small package, heavy weight air, LTL ground). Little integration of these legacy systems has taken place and even less integration has taken place between interlining carriers.

[15] The DOT Federal Highway Administration has developed data architecture for a standard automated documentation system called Electronic Freight Management and is in the process of seeking adoption by supply chain stakeholders. Concurrently, the Task Force on Critical Transportation Infrastructure in Europe has developed a tracking and tracing system architecture called ParcelCall and encouraged adoption by the commercial sector.

[16] For the purposes of this paper a supply chain owner is the partner with the vested business interest in the shipment arriving on-time and intact (e.g. NRC Licensee, DOE Contractor, Energy, Medical or Construction Company) and/or would be responsible for any government mandated exceptions reporting about the shipment.

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The commercial sector's success rely on its ability to have shipments in the right place at the right time. The ability to perform this function well is what separates the good from the great and is precisely why businesses guard their proprietary internal tracking systems with fervor. Nevertheless, when it comes to SSHM and RAMQC, all commercial supply chain partners share the same interest in tracking and visibility because the risk, liability, and public relations impacts are indiscriminant and mutual. There is no proprietary interest in the safety and security of SSHM and RAMQC; all partners suffer equally if a SSHM or RAMQC becomes a terrorist weapon or causes a heinous accident. Insurance costs, system delays, public safety, personnel training requirements, and public confidence are all shared concerns with equally bad consequences when one supply chain partner falls short.

The Regulatory Sector

A post 9/11 society expects, and the US Congress has mandated, that the regulatory sector have real-time exception-based reporting of SSHM and RAMQC incidents including immediate access to forensic commercial sector shipment information.

There are multiple regulatory sector SSHM and RAMQC supply chain tracking requirements. They all share two common characteristics: they are list-based and non-technology enabled. While these mandates have common SSHM and RAMQC reporting requirements, they lack integrated enforcement[17] and they mandate their own exceptions-based notification to applicable commercial sector supply chain partners.

There are common threads with mandated SSHM tracking regulations:

- The mandates are driven by similar security or safety threats.
- Federal and State agency SSHM and RAMQC tracking and exception-based reporting mandates are usually "stove piped" to the applicable commercial sector that falls under its jurisdiction.
- The hazmat supply chain transporter industry has traditionally relied on a single Federal/State regulator (i.e., the DOT) for the promulgation and consolidation of shipment safety and security requirements.[18]
- There is no regulatory mandate to communicate the SSHM and RAMQC designation to the transporter industry nor does the industry have an integrated system that handles such a mandate.

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[17] Enforcement of transportation safety and security regulations is shared between the Federal DOT and the State DOT. The majority of the day to day DOT enforcement burden, including hazmat, is placed on the States and is generally delegated to the State Police. There is no current formal relationship between NRC and State Police, so, changes in hazmat classification requirements, such as RAMQC, has no channel for filtering down to the enforcement officers.

[18] EPA requires transporters of hazardous waste to register but has harmonized these requirements in the 49 CFR hazmat transportation regulations.

Ultimately, there are two overarching issues in the current system.

- When a supply chain partner determines an SSHM or RAMQC shipment is lost, the decision to make immediate notification is a subjective judgment. Consequently, a RAMQC shipment or a trailer of consolidated hazmat meeting the SSHM or RAMQC definition could be lost for hours and even days before the regulatory sector is notified.
- Federal, State and local law enforcement personnel currently have no forensic information when notified of a SSHM or RAMQC shipment that is lost or damaged.

The IntelligentFreight Solution

ORNL Experience

ORNL has collaborated with EPA, DOC, EU, commercial sector transporters, and state enforcement agencies on several continuing projects associated with identifying, detecting, tagging, and remote tracking of Hazmat, RAM and other high-risk shipments in the air, motor, rail, water, and intermodal sectors.

The IntelligentFreight concept is the culmination of 8 years of ORNL research and development associated with the supply chain. The ongoing ORNL programs include:

- The EPA sponsored Radiological Source Tracking and Monitoring (RadSTraM).
- The Department of Commerce (DOC)-European Union (EU) jointly sponsored TEC-Lighthouse Project – Global Radiological Source Tracking and Monitoring (GradSTraM).
- The southeastern states sponsored Trusted Corridors program.
- The ORNL sponsored Sensorpedia project.
- The Office of Naval Research sponsored SensorNet© Program.
- The DHS sponsored Southeastern Transportation Corridor Pilot.
- The ORNL-KC SmartPort jointly sponsored Trade Data Exchange project.

In these programs multiple technologies have been investigated, prototyped, and deployed with the core research focused on supply chain sensor information sharing systems, both distributed and disparate.

Of particular relevance, the RadSTraM program[19] [20] has investigated the use of semi-passive RFID technologies for the tracking of RAM sealed sources throughout their product lifecycle. In September of

[19] ORNL continues to lead the EPA (RadSTraM) program which is now entering Phase III and includes a 2009 Global Demonstration Pilot

[20] *RadSTraM: Radiological Source Tracking and Monitoring, Phase II Final Report* Published January 2007 by ORNL for EPA. EPA RadSTraM Phase III is investigating the integration of RFID embedded in RAM packaging with radiation portal monitors deployed at the Knox County, TN Weigh and Inspection Station.1.)

2008 the DOC and the EU jointly announced a radioisotope tracking project in the transatlantic corridor to "help pave the way for other projects to increase the competitiveness of businesses on both sides of the Atlantic."[21] This program (GradSTraM) was leveraged from the ongoing RadSTraM sensor integration and information technology findings and supply chain partner integrations.

Technical Approach: Freeing Trapped Information

Most of the information needed by supply chain partners to provide for total asset visibility and exception-based reporting already exists inside numerous proprietary or agency-centric databases.

As previously noted post 9/11 congressional mandates have ratcheted up the need for granularity in shipment visibility. Regulations like NSTS and SSHM have motivated the commercial sector to seek solutions that will provide partner-to-partner visibility while giving the regulatory sector the real-time product visibility it requires. The ORNL conclusion is that 99% of the information needed by supply chain partners already exists but is trapped in proprietary or "stove piped" databases.

The collective technological solution for end-to-end visibility of the supply chain must address the following challenges:

- Integration of massive and proprietary enterprise commercial sector tracking systems.
- Establishment of a universal naming convention across multiple, incompatible enterprise systems.
- Integration of information from emerging tracking technologies and legacy tracking systems.
- Exploitation of legacy commercial and Federal databases to reveal query-driven information requests in real-time.
- Integration of discrete and micro-elements of the supply chain information base in a secure and efficient manner.

Establishing another defined and bounded information "system of systems" for RAMQC or SSHM tracking is not a cost-effective or realistic solution for the multi-billion dollar supply chain industry. Product codes do not exist that integrate the supply chain product manufacturers/users with the supply chain transporters.[22] Development of these standards will be useless if the commercial sector can't justify the business case.

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[21] The DOC-EU RFID isotope tracking pilot project is a result of the U.S.-EU framework for Advancing Transatlantic Economic Integration. The initial phase of the project will begin in 2009, involving the USPS, Royal Mail, the DOE Office of Science Isotope Program, ORNL and the National Physical Laboratory in Teddington, UK. The second phase of the project will begin in 2010, expanding the project to other US Agencies other EU countries.

[22] The transportation sector of the supply chain never adopted the UPC standard for tracking freight. The larger carriers use proprietary barcode based systems that do not integrate with UPC standards.

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Technical Solution: Web 2.0 and Supply Chain Data

RAMQC and SSHM commercial sector partner-to-partner visibility and regulatory sector exception-based reporting can be achieved with secured Web 2.0 information distribution technologies.

The national need for real-time tracking of SSHM and RAMQC provides the motivation for visibility into the supply chain, but there are no efficient real-time means to dispense discrete and disparate information between supply chain partners. The most important part of any solution for visibility will be the ability of all stakeholders in the commercial and regulatory sectors to retrieve, maintain, sort, and distribute faceted data and shipment intelligence in real-time. Numerous sensor-based tracking technologies are already in use, but there is no industry-wide integration of the information they collect. Emerging tracking solutions such as RFID could serve to fill the "black holes" of shipment visibility; however, the commercial sector business case for the investment has not established, nor does the infrastructure exist for costly industry-wide adoption.

ORNL's IntelligentFreight solution is based on two basic components:

- A Web 2.0 enabled portal with "security-enhanced social media" capabilities to connect the various supply chain stakeholders with each other and to assign a dynamic and persistent identity (encoded as a unique web address or Uniform Resource Locator (URL)[23]) on the fly. This address takes on the role of a permanent and unique *Virtual Resource Identifier (VRI)*[24], but does not require *a priori* agreement on a universal standard by all the stakeholders (a difficult and open ended process). The VRI permits otherwise incompatible standards to be linked to the same element.
- The ability to dynamically incorporate and associate searchable user-defined tags to the Virtual Resource Identifier. These tags are contributed incrementally by the various partners involved in the progress of the shipment, but they do not interfere with the seamless operation of the whole system.

[23] In Information Technology applications a URL is a type of Uniform Resource Identifier (URI) that specifies where an identified resource is available and the mechanism for retrieving it. It is more popularly called a web address.

[24] As noted earlier, the VRI construct remains un-mutable and exists past the lifetime of the product.

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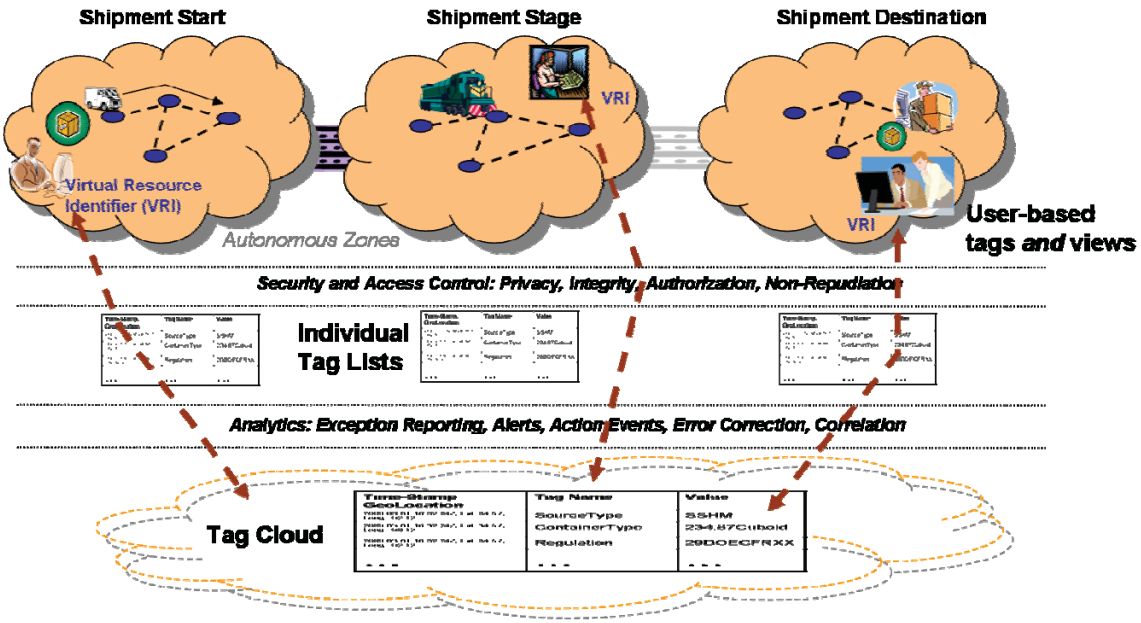

Figure 1: Intelligent Freight Concept

Figure 1 illustrates the technical solution architecture. At the starting point ofa shipment, rs the package is registered and assigned a Virtual Resource Identifier (VRI). By allowing an identifier to be created dynamically, the system becomes agnostic to origin – by region, by sector, by mode, by owner, and by regulation. Individual shippers (or partners in autonomous zones) add tag information to the package associating it with the VRI. This information is access controlled using well established security mechanisms. By allowing incremental tags to be associated with the shipment, the system becomes resilient and flexible to transfers between carriers and institutions, and at the same time can tolerate incorrect, partial, or faulty information. Individual users can look up the shipment or track it based purely on the tag information they have associated with the VRI, and they can retrieve and view the location of the shipment based on that tag information. Using access control and permissions, a shipper or transporter can allow or limit users from viewing proprietary information associated with the shipment. Importantly, if the VRI is lost, or if incorrect information is entered, an analytical search layer can retrieve the correct shipment based on "partial" information alone. The searchable association mechanism allows all steps in the supply chain to "get to what they want" for identification and visibility purposes.

The Path Forward

The path forward proposal starts with a real world demonstration project for the tracking of RAM in the international supply chain. Such a demonstration will:

- Create an secure "honest broker" portal prototype
- Develop a Web 2.0 universal *Virtual Resource Identifier* tagging prototype
- Baseline the inherited information databases available

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- Track the shipments using remote tracking technology(s)
- Distribute and receive tagged data using a Web 2.0 engine prototype
- Develop a security enhanced social media portal based on electronic shipping data tagging
- Develop automated exceptions-reporting distribution prototype
- Develop a query-enabled and knowledge-sharing search engine prototype.

The aforementioned technology attributes are readily available in the current Web 2.0 information management environment and can be rapidly adapted for supply chain requirements .

IntelligentFreight Prototype for RAM Tracking

The IntelligentFreight prototype would act as a security-enhanced Web 2.0 tracking clearinghouse for the collection and distribution of disparate and proprietary RAM supply chain data. The steps for implementing this prototype to support real-time tracking of RAM are:

1) Establish the social network web site *IntelligentFreight.org*[25] for tracking RAM shipments.

2) Register RAM shipping supply chain partners in *IntelligentFreight.org* using strong authentication to identify manufacturers, fabricators, end users, transporters, disposal facilities, Government users, etc.

3) Upon entering the supply chain, each RAM shipment is assigned a permanent, unique network link or URL by the RAM tracking web site *IntelligentFreight.org*. This is the IntelligentFreight *Virtual Resource Identifier* for the shipment.

4) The *IntelligentFreight.org* VRI will be shared, with appropriate read-write-search permissions among all partners involved in the supply chain shipment.

5) Using *IntelligentFreight.org* each partner will have the ability to tag the IntelligentFreight *Virtual Resource Identifier* record to facilitate enhanced browsing and searching capabilities. Tags within *IntelligentFreight.org* will be able to include carrier name, DOT, DHS, DOE and/or NRC classification, material type, or other user defined labels.[26]

6) Additional enterprise information associated with a shipment, including any unique enterprise tracking number, shipper's UPC/EPC, transporter's tracking code, or any identifying document, may be included as annotations to the IntelligentFreight *Virtual Resource Identifier*. These user-contributed annotations provide a summary of enterprise specific metadata and may reference

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[25] *IntelligentFreight.org* is a notional website that is being used in this example as the prototype tracking website.

[26] A tag is a non-hierarchical keyword or term assigned to a piece of information that describes an item and allows it to be found again by browsing or searching. The collection of tags for an item forms a "bottom-up" classification scheme and items are not limited to a single category within a hierarchy.

internal enterprise systems that may be accessed separately for further information. Annotations may also contain tags, supporting fine-grained search capability.

7) Any unique enterprise tracking number, shipper's UPC/EPC, transporter's tracking code, or any indentifying document will be able to be uploaded, referenced, or linked to *IntelligentFreight.org* as a reference to the tracked item.

8) If authorized, supply chain partners will have the ability to query the system with any number of tracking numbers, keywords, names, etc. Because each partner's tags are associated with the shipment's unique and permanent VRI, searches on *IntelligentFreight.org* will be able to locate the shipment record by any of the "tags" associated with the URL or *Virtual Resource Identifier*

9) At any RAM supply chain transfer point, the *Virtual Resource Identifier* can be access to provide additional tags and/or annotations containing new information from the authorized supply chain partner. All previous tags and annotations are preserved and are not overwritten.

10) The *Virtual Resource Identifier* can be accessed by authenticated RAM supply chain partners who have the appropriate read/write permissions to determine any number of data: where the shipment is, a record of how the shipment has been transported, inspections conducted; whatever other previous information that is referenced by the unique and permanent *Virtual Resource Identifier*.

11) When the shipment reaches its destination and is accepted, the receiver can electronically tag the shipment as completed.

12) The *Virtual Resource Identifier* can be recorded in any supply chain partner's internal tracking system and a shipping history will be available at *IntelligentFreight.org* in the event of post-shipment inspection, questions, or re-shipment.

13) The regulatory sector will have a "peer in" ability to allow them to find the history and current status of a RAM shipment by searching for the tags provided by any of the supply chain partners.

14) Law Enforcement and/or Emergency Response Agencies would be provided access on an immediate basis when an incident occurs via a pre-identified "virtual MSDS (Material Safety Data Sheet)" and/or UN/NA #[27] tag.

15) *IntelligentFreight.org* will make use of a unique and permanent URL, along with the user-supplied tags and annotations, supports common Web 2.0 services such as mash-ups[28],

[27] UN/NA #'s stand for United Nations or North American emergency response numbers, assigned by UN Competent Authorities to identify the universal hazard response to a specific hazmat shipment incident or accident. In the case of an NA number, the designation is only applicable on the North American continent.

interactive information visualization, and blogs to obtain instantaneous information and knowledge sharing

In the future emerging collective intelligence algorithms and other artificial intelligence technologies will be used to develop in-depth analysis and actionable intelligence for the international RAM supply chain.

Conclusion

"We are standing on the brink of a new ubiquitous computing and communication era, one that will radically transform our corporate, community, and personal spheres."

This Concept Paper describes an integrated SSHM and RAMQC international tracking system that provides end-to-end visibility and real-time exceptions-based reporting. It also presents a case for innovative and real-time partner-to-partner visibility and government-required exceptions reporting. A US/EU endorsed international RAM demonstration project starting in 2009 has already been established. The chance to leverage other like-motivated government and commercial stakeholders' investments has never been greater.

We are faced by staggering statistics (1 Billion people use Web 2.0 based social networking websites, and 154 Million people access over 1 Billion websites everyday) that are emblematic of our society's transformation. It is only natural to propose an approach based on such technologies to address our national SSHM and RAMQC tracking challenges. We have described how security enhanced Web 2.0 technologies can work innovatively, efficiently, and cost-effectively to track SSHM and RAMQC. The time is ripe for the *IntelligentFreight* concept to be applied to the global supply chain of such materials. The technology exists, the need is evident, and the motivation to act has manifested itself.

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[28]In web development, a mashup is a Web application that combines data from more than one source into a single integrated tool. The term Mashup implies easy, fast integration, frequently done by access to open APIs and data sources to produce results that were not the original goal of the data owners. An example is the use of cartographic data from Google Maps to add location information to real-estate data, thereby creating a new and distinct web service that was not originally provided by either source.

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