25th anniversary
annual INCOSE
international symposium
Seattle, WA
July 13 - 16, 2015

System of Systems Approaches for Mobile Source Transit Security

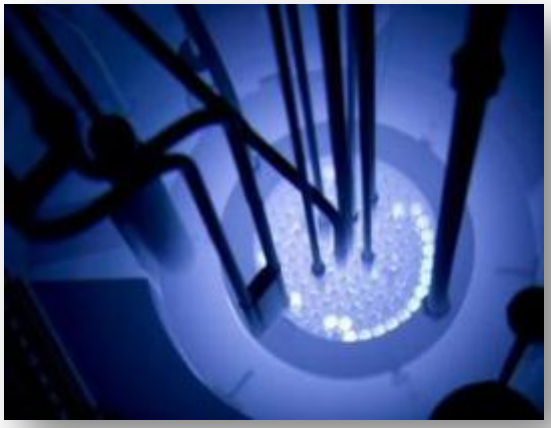
Fredrick Mauss, Juan Valencia, Brian Hatchell,
Kurt Silvers, and Shannon Crowell
Electronics and Measurement Systems Group
Pacific Northwest National Laboratory
P.O. Box 999
Richland, WA 99352, USA.
brian.hatchell@pnnl.gov

Outline

- Well-Logging Radiation Sources
- Threat Scenarios
- System Capabilities and Constraints
- Mobile Source Security Challenges
- System of Systems Pain Points
- Conceptual Design
- Conclusion

Defense Nuclear Nonproliferation Radiological Security Program

- The mission of the DNN RSP is to reduce and protect vulnerable radiological materials located at civilian sites worldwide
- The Radiological Security Program supports the protection of nuclear and radiological materials worldwide from theft and sabotage

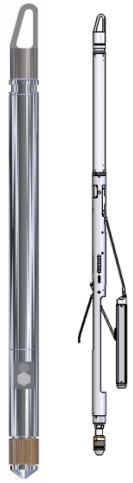


Radioactive Materials of Concern and Common Uses

Cs-137 (30 year half life):
Blood, research, and sterilization irradiators;
1,000 – 50,000 Ci

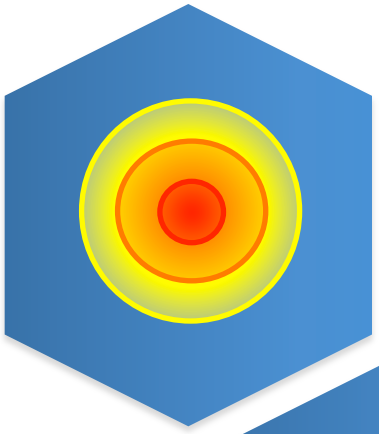
Co-60 (5 year half life):
Teletherapy and Gamma Knife units (cancer treatment);
1,000 – 10,000 Ci,
and panoramic irradiation (sterilization);
100,000 – 10,000,000 Ci

Ir-192 (73 day half life):
Brachytherapy (cancer treatment) and radiography (industrial imaging);
10 – 150 Ci



Am-241 (432 year half life):
Oil well-logging;
8 – 20 Ci

DNN RSP Approach to Implementing Security Enhancements



Graded Approach

Layered, target-out application,

Tailored to response strategy,

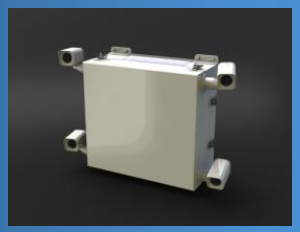
Based on material attractiveness.

Prompt detection,

Reliable notification,

Timely response initiation.

Alert and Notify Objective



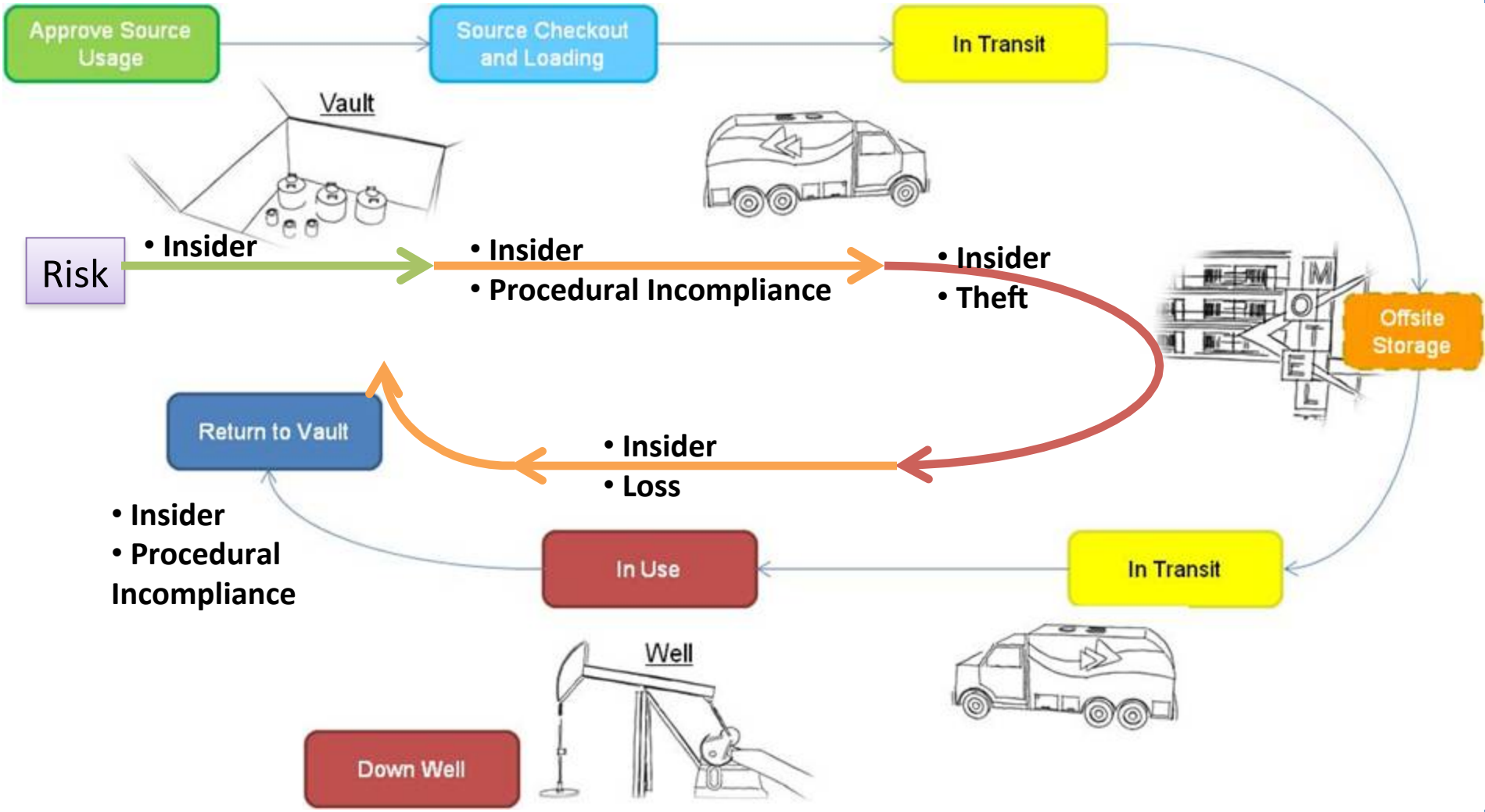
Insider Threat Mitigation

Critical alarms,

Continuously armed and supervised,

Received by multiple individuals/locations.

Mobile Source Operational Scenario



System Requirements

- Track the presence of the radiological source, not just the container, on the truck
- Automatically alert the appropriate commercial management if a radiation source is removed during transport
- Track the sources geographically to provide location status

System Constraints

The system shall be capable of operating globally where well-logging operations occur

The system shall not impact the safety and operational performance of the vehicle or transport vessel

The system shall use commercially available radiofrequency (RF) communication networks for reporting

- During explosive operations, the RF link shall be suspended unless the system has been qualified to be intrinsically safe

The system shall have low maintenance in operations, low purchase cost when in production, and no impact on the well-logging company's commercial activity

Mobile Source Security Challenges

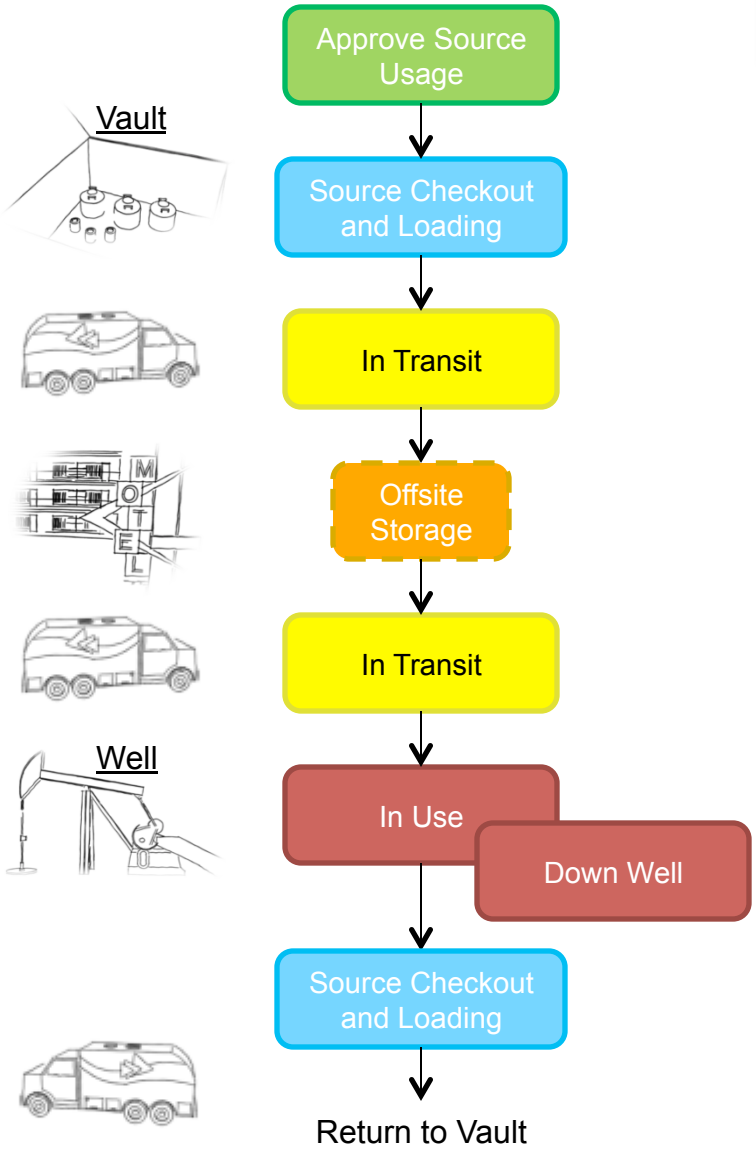
Characteristics of Mobile Devices	Security Challenges
Devices are portable and move from storage facilities, to transport vehicles, to job sites	• Security extends beyond storage location • Continuously tracking devices/containers and monitoring source presence
Transported and used across wide geographic areas	• Limited remote alarm notification and surveillance during transport and use
Used at job site for varying lengths of time	• Reliance on manual procedures and operator communication during transport and use
Used in harsh and remote locations	• Response jurisdictions can be difficult to determine • Device location may be unfamiliar to responders • Power consumption (battery life) • Alarm communication methods and reliability
Relatively small devices/containers	• Portability • Limited space for sensor and communication components

SoS Pain Points[1]

SoS Pain Point	Description
SoS Authorities	What are effective collaboration patterns in SoS? Each participating system has its own local 'owner' with its stakeholders, users, processes and development approach
Leadership	What are the roles and characteristics of effective SoS leaders? SoS leadership often requires softer forms of control, such as influence and incentives
Constituent Systems	What are effective approaches to integrating constituent systems? SoS's like the MSTS System are composed of service systems that were developed for cross-cutting purposes
Capabilities & Requirements	How can SE address SoS capabilities and requirements? Capabilities and constraints rather than requirements
Autonomy, Interdependencies & Emergence	How can SE address the complexities of SoS interdependencies and emergent behaviors? Strategies to sustain compatibility with evolving service systems
Testing, Validation & Learning	How can SE approach SoS validation, testing, and continuous learning in SoS?
SoS Principles	What are the key SoS thinking principles? Conceptualizing and modeling, complexity

2014 ICOSE Paper, "SoS Pain Points", Dr. Judith Dahmann

Well Logging Land Based Source Usage: Conceptual Design



System Controls and Notifications

Electronic inventory management

<u>Checkout</u>
- Default Run Mode Configuration
- Authorized User System Configuration
- System Validates Checkout and Load

<u>MCU Monitoring</u>
- Presence of shield eTags
- Radiation Detection
- System Tamper
- Geo-fence

<u>Alerts/Alarms</u>
- Messages sent to multiple users

<u>In Use Alarms</u>
- Alarm will be generated after a pre-determined amount of time elapses and the source have not updated status.

Mobile Source Tracking System

• Telematics

Mobile Alerts

Monitoring Station At Vault/Base Station

Approve Source Usage

In Transit

Vault

Risk

• Insider

• Insider
• Procedural Incompliance

• Insider
• Theft

Offsite Storage

Return to Vault

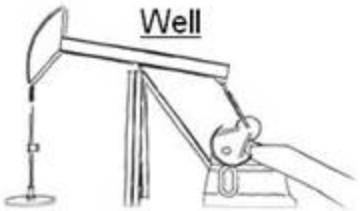
• Insider
• Loss

• Insider
• Procedural Incompliance

In Use

In Transit

Well



Down Well

Authorities

Telematics

Mobile Alerts

GeoForce

Monitoring Station At Vault/Base Station

DOE/DNN

Approve Source Usage

Source Checkout and Loading

In Transit

Baker Hughes

Shipping Transport in Foreign Countries

Risk

- Insider

- Insider
- Procedural Incompliance

- Insider
- Theft

Offsite Storage

Return to Vault

- Insider
- Loss

- Insider
- Procedural Incompliance

In Use

In Transit

Well

EXPLOSIVES

1

Well Site

Baker Hughes

Leadership

- Oil-Field Service Industry Partnership
  - Jointly developed “Security and Control of High-Activity Well Logging Sources Guidelines”
  - Addressed security of well logging sources in storage, in transit and in use at drill sites

- Industrial Radiography Security Initiative
  - Partnership between DNN RSP, the FBI, the Non-Destructive Testing Management Association, and individual radiography licensees
  - Outreach venue to raise risk/threat awareness and to discuss approaches to training and security upgrades

SECURITY AND CONTROL OF HIGH-ACTIVITY WELL LOGGING SOURCES GUIDELINES

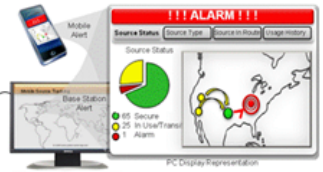
- Mobile Source Tracking
  - In 2012, DNN RSP met with representatives from each industry to discuss the status of their internal mobile source tracking efforts
  - Options for supporting these efforts were considered

Constituent System

GPS Power Usage
Telematics
Bandwidth

• Telematics

Mobile Alerts



Monitoring Station At Vault/Base Station

Approve Source Usage → Source Checkout and Loading → In Transit → Offsite Storage → In Transit → In Use → Return to Vault

Vault

Risk

• Insider

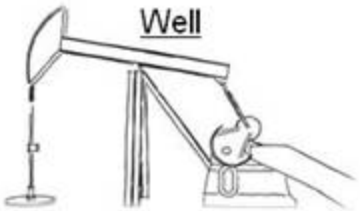
• Insider
• Procedural Incompliance

• Insider
• Theft

• Insider
• Loss

• Insider
• Procedural Incompliance

Well

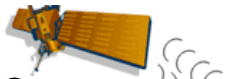


Well

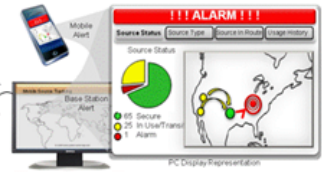
Intrinsic Safety at Well Site

Capabilities and Requirements

Telematics



Mobile Alerts



Monitoring Station At Vault/Base Station

Approve Source Usage

In Transit

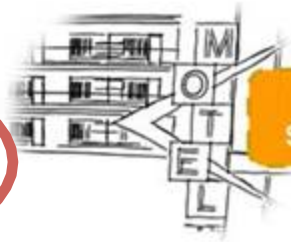
Vault

Risk

- Insider

- Insider
- Procedural Incompliance

- Insider
- Theft



Offsite Storage

Return to Vault

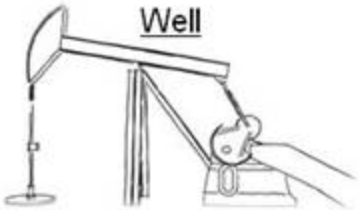
- Insider
- Loss

- Insider
- Procedural Incompliance

In Use

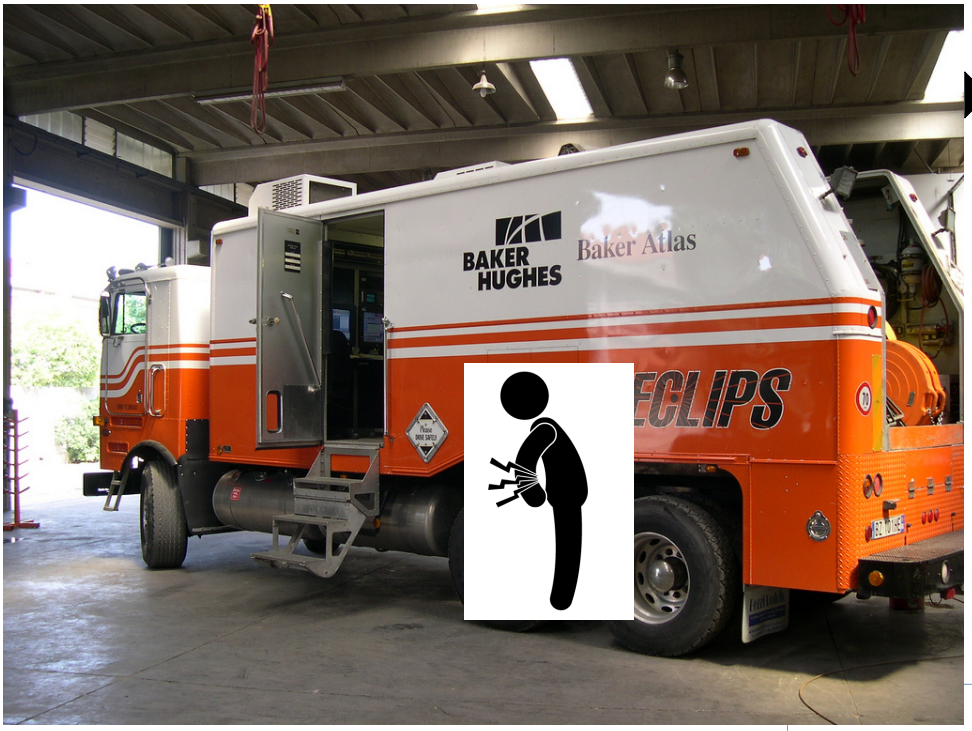
In Transit

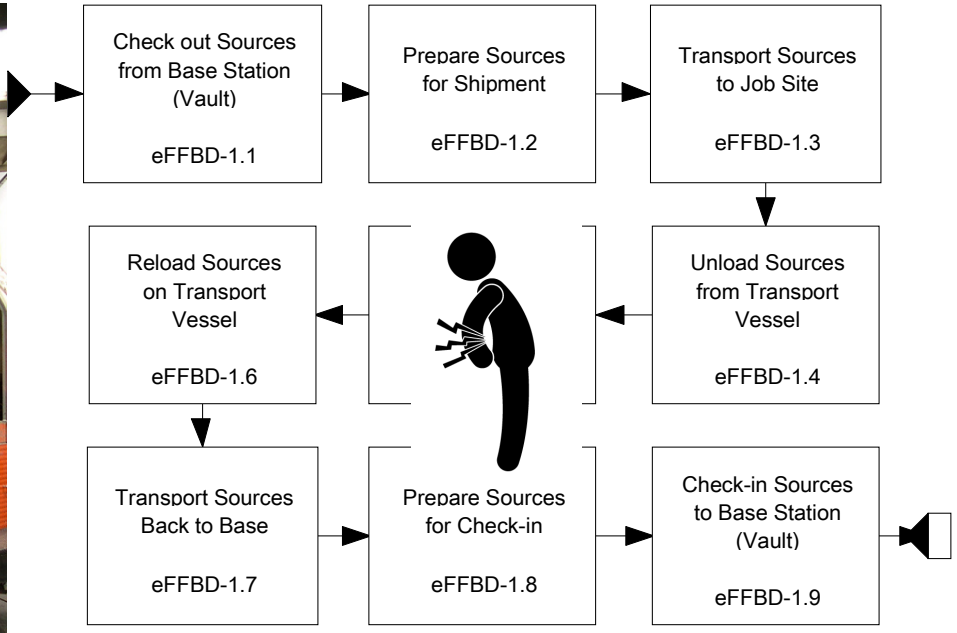
Well



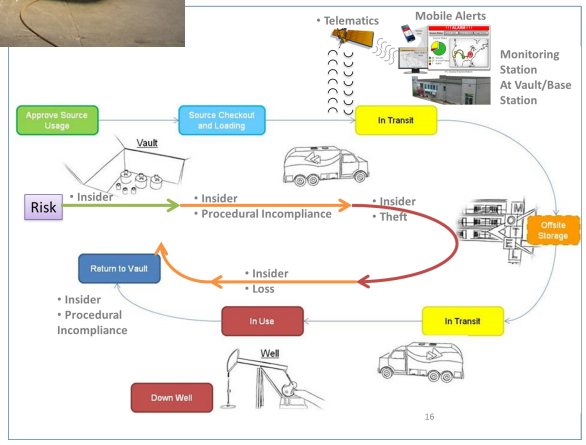
Down Well

Autonomy, Interdependence, and Emergence

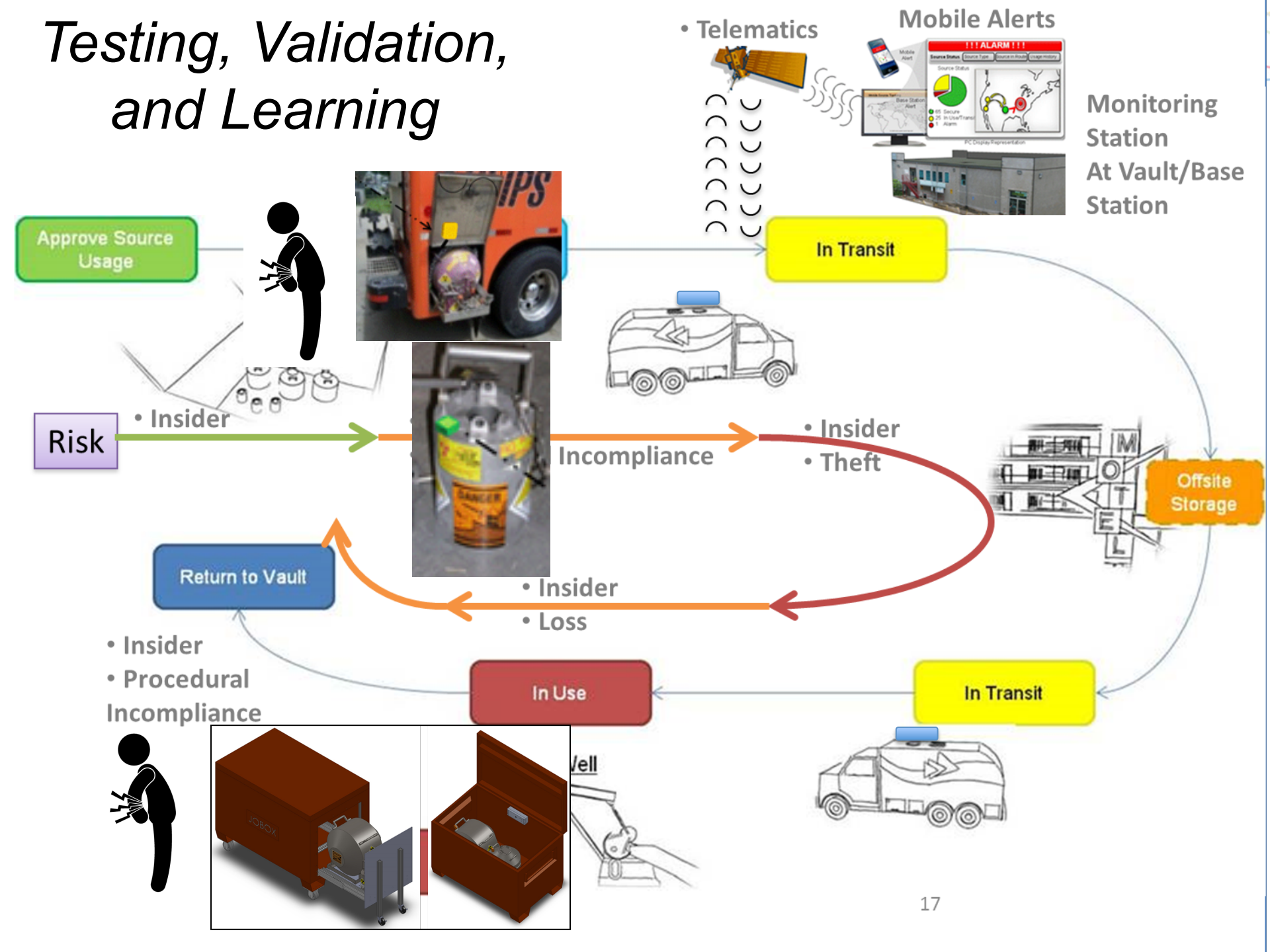




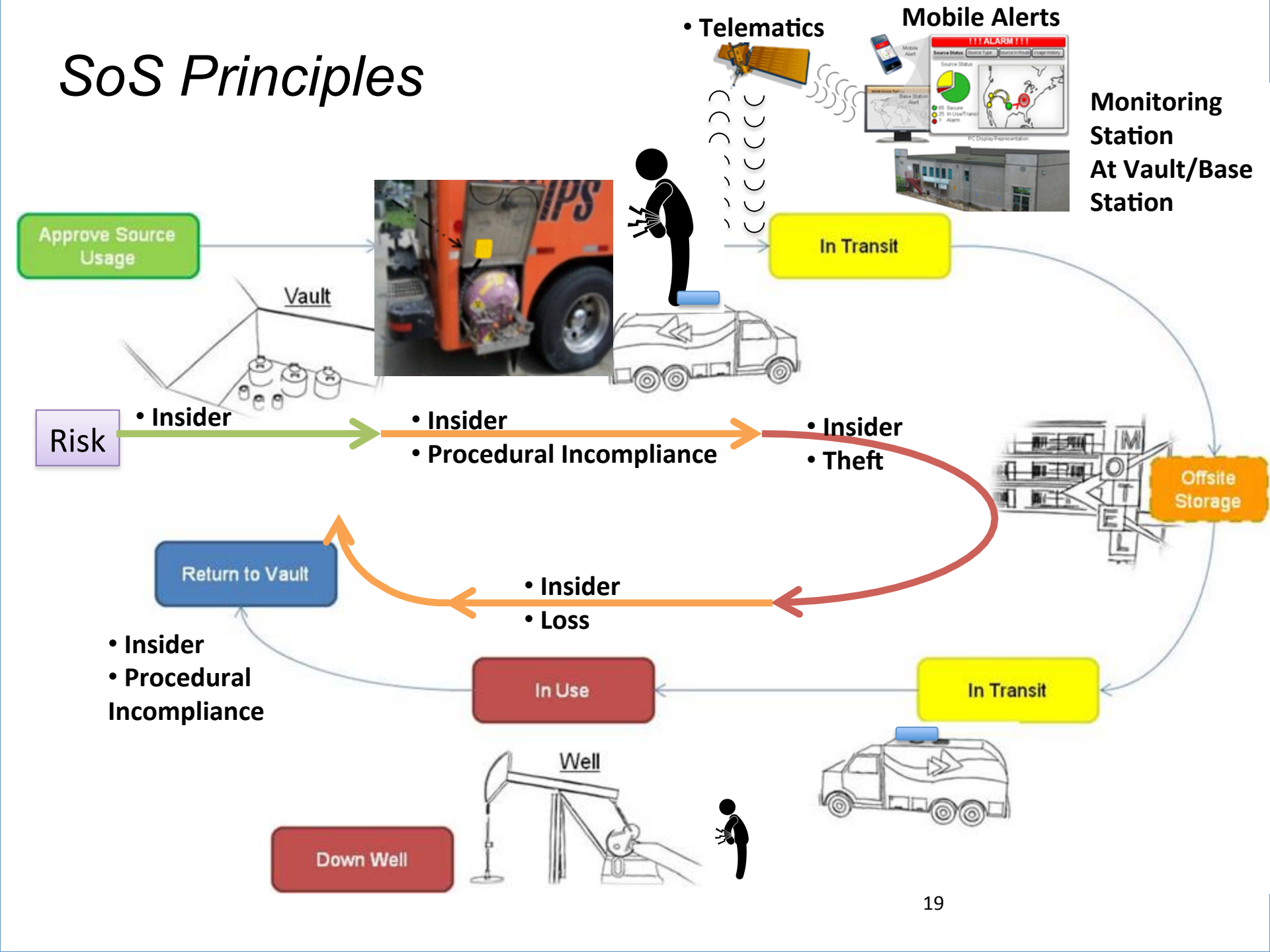
Modeling and pilot tests



Testing, Validation, and Learning



SoS Principles



System Benefits & Limitations

Benefits

- Timely notification of potential security incident
- More accurate locational data to target response/search area
- Insider threat mitigation
- Procedural compliance assurance
- Electronic inventory management

Limitations

- Cannot track individual sealed sources independent of their container
- Base system cannot continuously track devices/containers outside of RF range
  - Size and cost of satellite communication technology
  - Cellular communication coverage and cost
  - Power consumption

Conclusions

- SoS engineering approaches have been used to develop a system architecture consisting of custom electronics, commercially available telematics, and existing systems
- The Pain Points successfully illuminated SoS issues related to Mobile Source Transit Security