# Joint Direct Attack Munitions (JDAM)
# In-Transit Visibility (ITV) Viability Testing
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**The Joint Direct Attack Munitions (JDAM) In-Transit Visibility (ITV) project was originally designed to validate effective and *Hazards of Electromagnetic Radiation to Ordnance* (HERO) safe passive Radio Frequency Identification (pRFID) and Item Unique Identification (IUID) data capture across an ordnance supply chain. By better understanding how current automatic identification technology (AIT) can be applied in an ordnance environment, the Navy and Department of Defense (DoD) will be better able to make more informed policy decisions about the application of these technologies and improve business processes for all classes of supply and across the entire supply chain. The broader commercial RFID industry also has much to gain by these advances within DoD, to the extent that it drives innovation and understanding of RFID use in close proximity to metal and explosives.**

**This white paper provides an overview of the Navy AIT Office-sponsored JDAM ITV project and describes the first phase of efforts executed to date, demonstrating pRFID can, in the future, be viably employed onboard Navy ships.**

## Section I: Overview

DoD supply chain management policy is focused on achieving Total Asset Visibility (TAV) throughout the supply chain in support of warfighter operations. Enabling data transactions that offer joint visibility and deploying new data collection technologies provides strategic benefits, including:

- Improved asset identification and management,
- Near real-time asset visibility, and
- Optimized process improvements across the DoD logistics supply chain.

By capturing data electronically with AIT and incorporating it into business transactions, DoD is able to move assets through the supply chain more efficiently. These data can be more accurately, effectively, and reliably fed to automated information systems (AIS), providing for improved asset, container, or shipment visibility, including information about location and condition. pRFID and two-dimensional data matrix barcodes are two AITs that are currently viable within parameters of DoD RFID and IUID policy.

Currently, DoD policy for pRFID use throughout the numbered shipping layers *does not* apply onboard Navy ships due to safety concerns of using radio frequency technology around and near explosive ordnance. Any AIT used where ordnance is received or distributed must meet strict Hazards of Electromagnetic Radiation to Ordnance (HERO) and electromagnetic interference (EMI) constraints, forcing use of less-than-optimal methods of managing the flow of assets through the supply chain, including:

- Handwritten tracking methods,
- Linear tracking methods, and
- 2D barcode methods.

HERO Warnings

Unavailable, difficult to use, or incompatible data often necessitates significant reliance on manual data entry into automated information systems. The sheer number of barcode labels and the effect of their positioning on items moving through the supply chain only exacerbate the need for intensive hands-on labor to complete all business processes aimed at getting supplies to the warfighter. The Navy's current intention is to maximize use of pRFID technology in order to minimize the need for manual data collection processes across the supply chain.

This is not to imply that the use of pRFID in tracking assets will decrease the number of workers needed, or the number of jobs available. If barcode readers or pRFID handheld readers are used in lieu of fixed interrogators, the number of personnel needed would remain the same. The true labor benefit of an installed pRFID system would be the ability to rely on the automatic data collection accuracy, and spend less valuable time doing research on transfer documents discrepancies, spot inventories, etc. Time could then be devoted to other, more value added activities.

## Section II: Pre-Testing Preparations

With a supply chain view in mind, site surveys were conducted aboard the USNS Lewis & Clark and the USS Eisenhower, and at the US Army's Anniston Defense Munitions Center (ADMC). Actual testing was conducted aboard the USNS Lewis & Clark in September 2010. Team members involved in this proof of concept were:

- Naval Supply Systems Command (NAVSUP) – Sponsor
- Naval Operational Logistics Support Center (NOLSC) - Program Management
- XIO Strategies, Project Lead
- Alien Technologies, Equipment Supplier
- GlobeRanger, Software Provider
- North Dakota State University, Read Range Assessment
- Naval Surface Warfare Center Dahlgren Division (NSWCDD Q52), HERO Assessment

Staff from the Naval Surface Warfare Center - Dahlgren; Q52, E3 Assessment & Evaluation Branch (NSWC – Dahlgren Q52) spent valuable time in advance of shipboard testing to help XIO Strategies' partner, Alien Technologies Inc., understand what HERO/EMI limits might be expected during an actual test aboard a Navy ship. Alien visited Dahlgren and determined the measurements of Safe Separation Distance and Total Radiated Power for two RFID readers, allowing Alien to work in its own labs to adjust equipment in advance of testing.

In order to properly prepare and execute a test aboard an active ship, visits of potential test ships were conducted to allow participants to evaluate logical test locations based on ship's resupply, storage, and issue operations. Site surveys of the USNS Lewis & Clark and the USS Eisenhower, and at the ADMC, revealed the following results:

<u>USNS Lewis & Clark</u>

- The best locations for testing were deemed to be the port-side and starboard-side clearways near the ships' helicopter hanger, and in a storage hold.

USNS Lewis and Clark

<u>USS Eisenhower</u>

- Aircraft carrier testing would require a much more elaborate protocol to sufficiently deal with numerous potential variances.
- Any kind of pRFID portal was immediately deemed impractical on the hanger deck; the size of the hanger doors ruled out a pRFID portal.
- An effective test on the USS Eisenhower in a weapons elevator needed to be preceded by additional advance planning, research, and coordination with a shore-based Weapons Elevator Support Unit.
  - That advance work would first include working with the Philadelphia Navy Elevator Support Facility to determine best test locations, protocols, and whether or not testing could be done ashore first in a mock-up site.
  - After careful evaluation, it was determined that testing aboard a CVN would not be immediately pursued.

<u>Anniston Defense Munitions Center</u>

- Team members agreed that any location would yield a successful test of pRFID technology within HERO constraints, but that time constraints forced a focus on shipboard testing.

Because of special safety concerns and current DoD restrictions placed on pRFID use in the vicinity of ordnance, previous pRFID testing has generally avoided involving explosive ordnance materiel. Additionally, ordnance materiel has specially designed packaging known to have negative effects on pRFID tag readability. For instance, metal alloy containers and irregular shapes can limit tag placement and affect tag reads by an interrogator. For safety reasons, only inert ordnance items and other supplies mimicking packaged ordnance items were used in testing. Since these substitutions utilize the same containers, or have similar packaging material, their use in no way invalidated test results.

## Section III: Test Approach

To ensure testing aboard the USNS Lewis & Clark was conducted within HERO parameters, staff from the NSWC – Dahlgren Q52 were present for all testing, and monitored the RF field strength created when the pRFID interrogators were transmitting in each test location while tests were being conducted. All readings were within the HERO safe levels established by *NAVSEA OP 3565/NAVAIR 16-1-529 VOLUME 2, Electromagnetic Radiation Hazards (Hazards to Ordnance)*.

pRFID data collection equipment and cabling used in the tests were not designed for extended exposure to outdoor weather and salt spray. The area of possible coverage is in the vicinity of the large helicopter pad and the eight cargo weather deck transfer stations, and would be difficult to adequately cover using pRFID due to the expansive area and lack of weather deck choke points. Therefore, the expected practical difficulties of maintaining such a system on the weather decks in an operational situation was assumed problematic and not considered to be a viable testing option.

Despite the focus, discussion, and planning to accommodate the testing of pRFID-tagged JDAM guidance set containers, none were actually tested aboard the USNS Lewis & Clark. Discussions and plans had been made to have empty JDAM containers labeled with compliant pRFID tags available for testing proved more complicated than could be supported by the ship's availability schedule. However, testing was completed with a variety of simulated cargo mimicking the types of cargo configurations one would expect to see aboard a T-AKE class ship. Simulated cargo included:

MK 46 Torpedo Container

- MK 46 torpedo container
- load of 54 inert 5" blank loaded and plugged projectiles
- load of six inert MK 82 500lb general purpose bombs
- pallet of shrink wrapped supplies (liquids included)
- semi loaded tri-wall container and
- semi loaded "war wagon"

Testing began after equipment was in place and consisted of a forklift being driven back and forth through the portal a specified number of times while read data was collected for each pass. Each simulated cargo load was tested using the same methodology. Forklift drivers were asked to make passes at the fastest speed allowed under normal operating conditions — a couple of miles an hour, or a

walking pace. The initial concern was that the speed of forklift travel might affect read rates observed; forklift drivers and the ship's cargo mate indicated vehicle speeds were dependent upon any number of factors, including crew activity in the clearway, ongoing ship operations while at sea, the type of cargo being moved, etc.

Items being transported near the RFID implementation site

Even at the faster clearway travel speed, tag reads were acquired. It was, however, observed that outbound items passed interrogators too fast and the tag read rate was significantly reduced.

The planned tests were completed earlier than anticipated, so an impromptu test was conducted inside the cargo elevator serving the test magazine. pRFID interrogators were placed on both sides of the elevator and simulated cargo was placed on the elevator car. Readers were triggered manually with the elevator doors open, as well as closed as far as possible (to within ~ 1"). NSWC – Dahlgren captured readings at the same time testing was performed for later analysis.

## Section IV: Test Results

Tag read rates were usually 100%, assuming a read of at least one of four tags placed on a cargo load as sufficient to identify the item; that is, at least one tag on a container was read and thus the system recognized that a cargo container passed through the portal.

Not surprisingly, tag read rates were influenced by the material on which the tags were mounted. Some pRFID test tags were intentionally mounted close to metal and expectedly had dramatically lower read rates than tags closer to being in free air. Tag read rates on the port-side clearway were influenced by the placement of the motion detectors and the inbound angles set on the antennas. Items traveling outbound with the load on the leading edge had read rates approximately 50% of the read rates of the other orientations and directions. The load was simply not in the read zone long enough to obtain a tag read.

The following chart summarizes the test results.

| | Test | Success Rate (%) | Notes |
|---|---|---|---|
| **Port-Side Clearway Test Cases** | 5” projectile load | 100% | |
| | 5” projectile load with a diesel forklift | 97% | Failed read occurred due to setup direction/orientation causing poor reads |
| | 500 lb bomb load | 100% | Exhibited great sensitivity to tag placement |
| | MK 46 Torpedo container | 100% | |
| | Shrink wrapped pallet w/ liquids | 100% | Exhibited great sensitivity to tag placement against the load |
| | Loaded war wagon | 100% | Exhibited great sensitivity to tag placement against the load |
| | Loaded tri-wall container | 100% | |
| **Cargo Hold/Ordnance Magazine Test Cases** | 5” projectile load | 98% | |
| | 500 lb bomb rack | 81% | Diesel forklifts are not operated below decks; exhibited great sensitivity to tag placement |
| | MK 46 Torpedo container | 100% | Metal mount tag performed very well, even in a single location |
| | Loaded war wagon | 100% | Metal mount tag performed exceptionally well |
| | Loaded tri-wall container | 69% | An un-noted abnormality appeared to be present in during the second half of the testing conducted and test participants are suspicious of the accuracy of the tag reads for this test |
| **Inside Elevator Test Cases** | Elevator doors open | ammo loads 100% war wagon 40% | |
| | Elevator doors closed | ammo loads 100% war wagon 100% | Closing the elevator doors improved read rates |

## Section V: Conclusions

***Testing onboard the USNS Lewis & Clark provided excellent data to begin identifying what the best shipboard application of pRFID might be.*** A sound understanding of pRFID performance characteristics is needed if the technology is to be approved for use with or near ordnance materiel within HERO restrictions. While the testing did not involve JDAM guidance set containers, the variety of materials passed through test portals was considerably more representative of the types most commonly transported aboard a T-AKE.

***The results show clearly that, at a container level, the cargo passing through test portals were recognized almost 100% of the time.*** The testing was designed to show the technology could work safely and effectively within HERO constraints. Since the opportunity availed itself, tags were placed to see to what degree portal readers could indentify container contents. When testing the tri-wall and war wagon, the containers were in fact recognized by the portal, but all of the containers' contents were not necessarily recognized. This does not mean the technology can't identify container contents, but rather that additional testing is needed if this level of visibility is desired.

***Depending on the visibility desired, processes may need to evolve or technology may need to mature further.*** In all likelihood, any successful implementation of pRFID technology in the Navy supply chain aboard ships will require changes in both process and technology. This project's first phase should allay any concerns about the safety or potential effectiveness of the technology while pointing to logical next steps for validating the viability of pRFID use from both a technical and business perspective.

***About XIO Strategies, Inc:*** *XIO Strategies, a Vienna, Virginia-based woman-owned business, specializes in developing and delivering end-to-end supply chain management services and solutions that enable improved asset visibility across the federal government and in commercial organizations. XIO works with its customers to improve business processes, manage technology deployment, conduct research and training, and design and launch marketing and communications programs. Through our work in policy planning, process analysis, and deployment of the next generation of AIT tools, the XIO team strives to optimize supply chain processes so they are poised to propel our clients forward. For more information, visit www.xiostrategies.com.*