NCIT **National Center for Intermodal Transportation**

A Partnership Between the University of Denver and Mississippi State

A PRELIMINARY DEMONSTRATION OF "VIRTUAL WAREHOUSING" AND CROSS-DOCKING TECHNIQUE WITH ACTIVE RFID COMBINED WITH ASSET TRACKING EQUIPMENT.

Prepared
By
Dr. Patrick Sherry
University of Denver
National Center for Intermodal Transportation

&

Rocque Kramer
System Planning Corporation
GlobalTrak
National Center for Intermodal Transportation

THE UNIVERSITY OF DENVER
AND
SYSTEM PLANNING CORPORATION'S GLOBALTRAK CONCEPT.
NOVEMBER 2010

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EXECUTIVE SUMMARY

The University of Denver’s Intermodal Transportation Institute and System Planning Corporation’s GlobalTrak system have successfully demonstrated the integration of GPS tracking and active RFID monitoring of simulated cargo of pallet and carton sizes by a mobile data collection and reporting device during a cross-country, intermodal transit involving truck and rail segments for two containers.

The success of this test indicates that it is possible to receive information about the location and condition of cargo throughout the transportation cycle, not just at nodes like transshipment or distribution centers. The use of RFID-tagged cartons and pallets with a GPS tracking device means that LCL/LTL loads as well as container/trailer-loads can be tracked and monitored during transit, extending the warehouse onto the road.

The pallets and cartons comprising the simulated cargo were tagged, placed in 53’ containers, transported, and brought together in Denver for a cross-docking maneuver. The tagged “cargo” was moved from one conveyance to the other and then associated with that new conveyance’s tracking device. The tag reads were reported by the respective devices and presented as meaningful cargo data on the GlobalTrak Information Management Bureau network site established for NCIT.

In this test, one 53’ container was loaded near the GlobalTrak facility in Arlington, VA and trucked to Harrisburg, PA where it was placed on CSX double stacked railcars and moved to the CSX intermodal yard south of Chicago. The container was then trucked, as is normally done, to the UP yard in western Chicago and double stacked on a railcar for the completion of the journey to Denver. From the Denver UP yard it was drayed to a hub in North Denver. A second 53’ container was obtained in Denver and trucked to the hub for a cross-docking event to occur with the containers within 8’ of each other.

Cartons and simulated pallets loaded in Denver and associated with the Denver GlobalTrak asset management unit, or AMU, were then switched with the cargo that had just arrived from Arlington VA. The Denver cargo was associated with the Arlington VA-origin AMU. The Arlington VA cargo was associated with the Denver AMU in its new container. Both AMUs’ reported their tagged cargo to the GlobalTrak Information Management Bureau as new cargo but also recognized the movement from one container to another.

The container loaded in and sent from Arlington VA initially reported its door open and closed during the loading cycle; and reported its location every hour and the status of the active RFID tags within the container more often. No alarms were reported until door opening in Denver at the cross-docking operation.

On completing the cross-docking, both containers were pulled off the docks and stored in the yard for one day. The Arlington VA container with new RFID tagged cargo was sent back to Virginia. The Denver container was driven around Denver where one pallet was unloaded to test a last mile delivery scenario. The cargo which was loaded in Arlington VA and cross-docked to the second container in Denver was eventually off-loaded and stored at the University of Denver campus where it remains today. It continues to report its location and status within the facilities of ITI to an AMU.

This test demonstrated the availability of improved delivery speeds through the coordination and scheduling of multiple containers from long-haul locations for cross-docking; a potential reduction in the costs of both inventory and materials handling; and a potential reduction in warehouse storage space requirements.

DEMONSTRATION PROJECT GOALS

The goals of this demonstration with the Intermodal Transportation Institute and GlobalTrak were:

A. Demonstrate the feasibility of tracking and monitoring active RFID tagged cargo while on a truck/rail intermodal transport outside of a laboratory environment.
Demonstrated as a qualified success.

B. Determine the reporting capabilities of RFID tags in a large metal container (53' intermodal containers) where the RFID reading devices were at varying distances from the readers. (See cargo placement maps)
Some undefined variables were present which complicated the analysis, but did not negate the general results.

C. Integrate reported RFID tag information into GlobalTrak's Information Management Bureau for online access display by cargo owners and supply chain partners.
Web-page was quickly re-drawn to include active RFID information and assignment.

D. Track the location and condition of the cargo on an hourly basis.
Hourly reporting was not an issue in terms of diminished battery capacity.

E. Detail the progress of the shipment with breadcrumb plotting of the movement with both maps and overhead imagery.
Successfully demonstrated with the additional benefit of visibility to the SKU.

F. Count false reports and anomalies of RFID tags in terms of statistical relevance.
Indeterminate results. Continue to factor data.

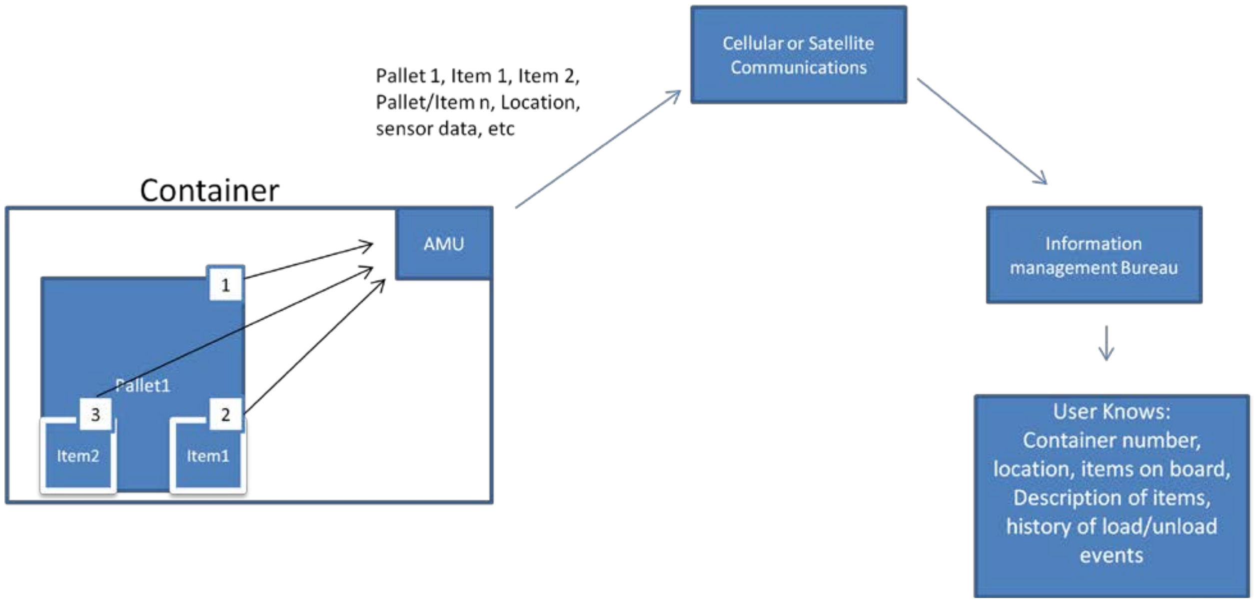
G. Demonstrate ease of system installation for the technically non-adept.
Proved by Dr. Sherry's single-handed installation of components at cross-docking site.

H. Demonstrate ease of access to partitioned information to various custody managers from the 3PL (Pacer) to hub and shipping managers.
All parties to the demo were able to access the data via the partitioned website which would enable all custodians of the cargo to do the same in future applications.

I. Demonstrate of relevance of tracking and monitoring cargo to the LCL or LTL level.
Partially demonstrated. Capable of tracking LCL or LTL away from conveyance but did not do so in this instance.

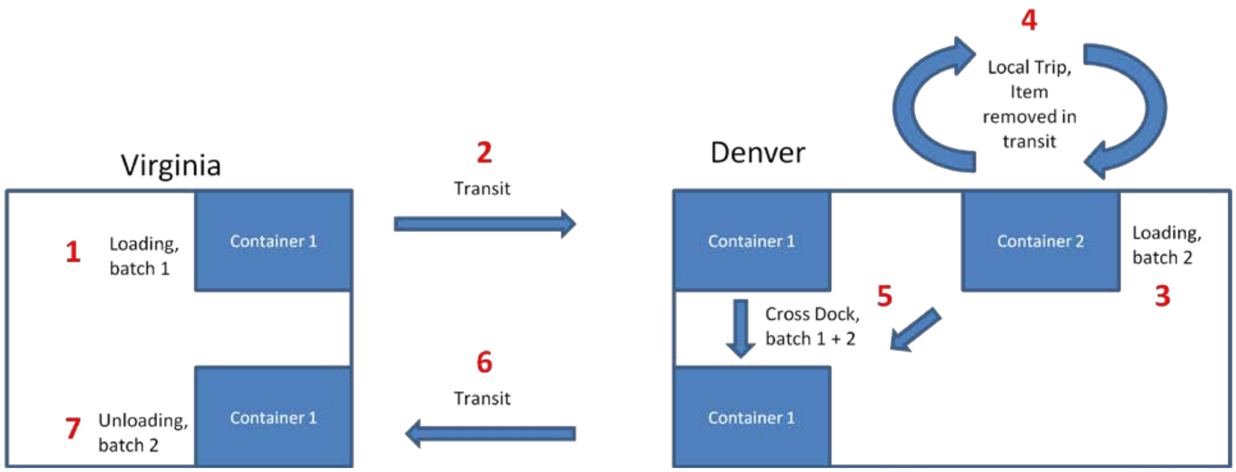
Overview

The high level system architecture is shown below:



- Asset Monitoring Unit (AM) – Asset Monitoring Unit (AMU) equipped with GPS receiver, satellite and cellular communications, and an active RFID reader
- Items and Pallets – Boxes with active RFID tags attached that communicate
- Cellular and Satellite Communications Networks – the GlobalTrak wedge is equipped with Orbcomm satellite and GSM cellular communications modems
- GlobalTrak Information Management Bureau (IMB) – the IMB is used to process device signals, setup a trip, track and monitor, and show current/historical view of item/pallet load/unload events

Below is a diagram of the test process:



1. <u>Loading, Batch 1</u> – 8 pallet sized boxes with RFID tags each containing 2 carton sized boxes with RFID tags is loaded into Container 1 in Virginia. The loading events are captured in the IMB
2. <u>Transit</u> – Container 1 is monitored while in transit to Denver
3. <u>Loading, Batch 2</u> – Container 2 arrives in Denver. 8 pallet sized boxes with RFID tags each containing 2 carton sized boxes with RFID tags are loaded. The loading events are captured in the IMB
4. <u>Local Trip, Item removed in transit</u> – Container 2 goes on a local journey. During the trip, one box is removed from the load. The container returns to the origin where the container was loaded. The IMB will sense that an item was removed while in transit
5. <u>Cross dock, batch 1+2</u> – the contents of container 1 are loaded into container 2, the contents of container 2 are loaded into container 1. The doors on both containers are closed. A log of the load/unload events is in the IMB
    a. Trip/test for container 2 is completed
6. <u>Transit</u> – Container 1 is monitored while in transit back to Virginia
7. <u>Unloading, batch 2</u> – Container 1 arrives in Virginia and is unloaded. A log of all load/unload events is available in the IMB
    a. Trip/test for container1 is completed

Additional Notes:

- All events created/collected during the journey are available in real-time in the IMB
- All events created/collected during the journey are stored for auditing
- History can be viewed at any time during the trip

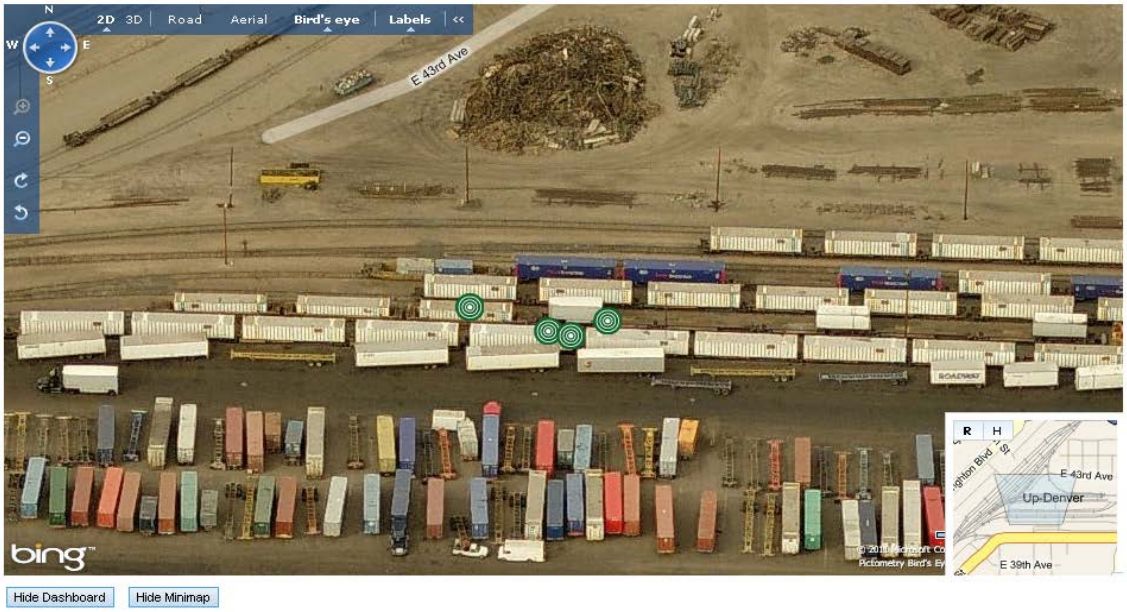
DESCRIPTION OF INTERMODAL ACTIVITY

PLOTS OF CONTAINER LOCATION AT SMALLEST SCALE

In conjunction with PACER 3PL, two 53' intermodal containers were rented by ITI and System Planning Corporation's GlobalTrak. One departed from Arlington, VA destined for the University of Denver's Institute of Intermodal Transportation. The other was originated and held in the Denver area until the Arlington VA container reached the UP yard in North Denver.

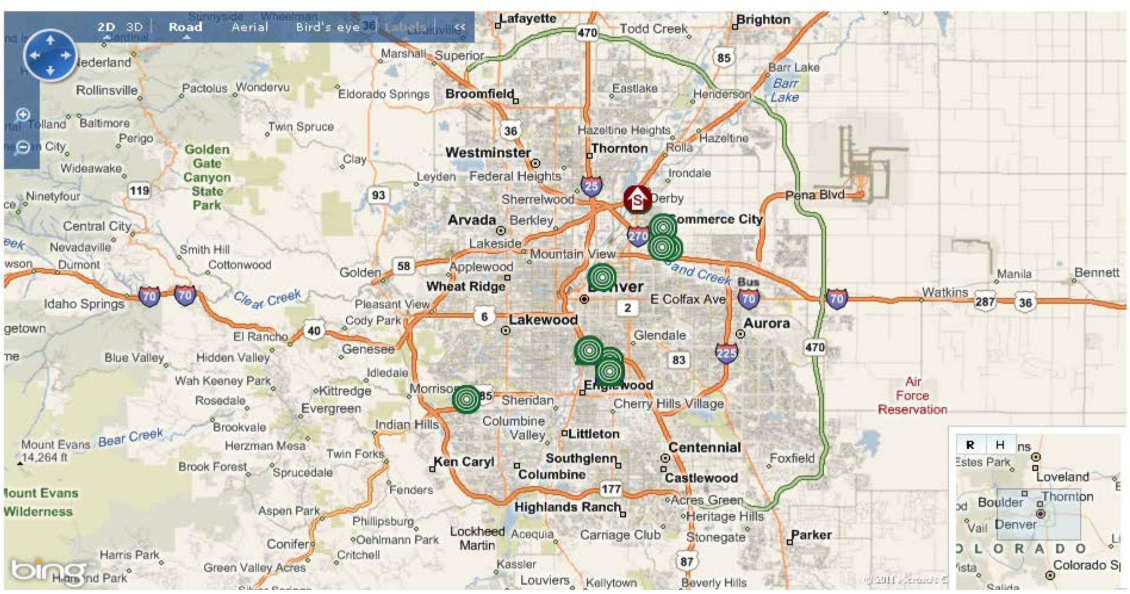
Both containers were filled with simulated cargo consisting of eight large pallet boxes with RFID tags adhered and two smaller tagged cartons placed inside each of the large pallet/cartons. The pallets were distributed throughout the container at varying distances from the active RFID reader integrated in the GlobalTrak asset monitoring unit (AMU). The AMU acts as a collector of sensor data, in this case GPS location data and reads of active RFID tags, which it then transmits by cell or satellite to the GlobalTrak Information Management Bureau (IMB) for processing, display, and access.

The Arlington VA container was delivered to the GlobalTrak facilities by truck where the simulated cargo with RFID tags was loaded. Reports by the AMU onboard to the IMB showed that the cargo doors had been opened and closed during the loading process and that all of the RFID tags associated with the cargo were reporting. A bill of lading was provided to the driver and the container was hauled to Harrisburg, PA for transfer to a CSX train. CSX took the container to South Chicago where the container was moved via a local truck to the UP yard west of Chicago. This east-to-west movement took five days to occur. Eventually, the container was double stacked and moved to Denver via Wyoming. From the Denver UP yard the container was drayed to a hub where it was placed in dock space adjacent to the Denver container configured and loaded by ITI.



Plots overlaid on Bing imagery showing container in a DENVER UP rail yard

The Denver container was loaded with simulated, tagged cargo and tracking equipment was installed. On the arrival of the Arlington VA container, a truck moved the Denver container to the loading dock where its cargo was transferred to the Arlington VA container and the Denver cargo was placed in the container that originated in Arlington Va. What had been Arlington VA cargo was driven around Denver in the Denver container, dropped off a tagged carton to simulate delivery, and returned to the yard for an overnight stay. Tracking data on the IMB followed this activity.



Denver Container Plots

Denver Cross-docking of RFID tagged cargo.

University of Denver plots of AMU after cross-docking.

The Arlington VA container was then returned by truck to the UP yard in Denver and shipped back to GlobalTrak facilities in Arlington VA over the same path it took for delivery to Denver. Again data was consistent.

CAPTURED TEST DATA

A significant amount of data was collected during the test. The data falls into 2 categories: a) messages/updates from loading and unloading events and b) messages/updates based on a regularly scheduled reporting interval from the Asset Monitoring Unit.

Key points on the data collected:

- Standard position reports
    - Position reports were transmitted by the AMU to the Information along the route (screenshots provided in other portions of this document).
    - There were approximately 500 AMU reports collected during the trial.
    - During the transit back to Arlington, VA the battery on the AMU drained completely and portions of the return journey were not captured.
- RFID load and unload events
    - Loading and unloading events for all of the tagged cargo was captured by the device and transmitted to the Information Management Bureau.
    - The device reported ‘phantom’ reads at times during the transit. This occurs at the RFID reader level and requires filtering in the Information Management Bureau (IMB) to compare raw tag reads with registered tags
    - The RFID tags would fall out of range at various points of the transit then come back into range. This would result in an extra load/unload event while the container was in transit. This can be prevented by fine tuning the RFID reader settings (duration for which the reader is active and at what interval the reader is turned on). The Information Management Bureau can also include other filtering business rules (such as if the asset is in motion ignore load/unload events, etc)
    - The unnecessary load/unload events contributed to the prematurely drained battery of the AMU on its return voyage due to the RFID reader waking the AMU more frequently than expected.

GENERAL RESULTS

CONTAINER BREADCRUMB

We were able to successfully demonstrate the ability to track both the container and eight large cartons simulating tagged cargo while in transit. Hourly reports were generated by the Asset Management Unit in terms of its geolocation, time of day, door status, and RFID tag presence within the container. A history was kept of this movement and stored within the Information Management Bureau (IMB) and displayed on a dedicated ITI partition within the database system. In this application GlobalTrak was essentially treating the cargo tags as sensed items and reporting the presence of their RF chirps.

DATA INTEGRATION

The IMB was formatted for the receipt of tag presence information and location. It was displayed on the ITI demo page as a table indicating the RFID functionality and association with the appropriate AMU. In the future this information could be expanded to include more descriptive information about the tagged item, i.e., color, size, style, weight, etc.

24 RFID tags read after device is installed and turned on

Event Type	AMUID	RFID Tag ID	Timestamp (GMT)	Latitude	Longitude	Door State	Light % Full Scale
TRCK.LR.DEF.GPRS	M12720600431		2010-11-01 23:00:26.0	40.31437101	-76.89253192	CLOSED	0.5
TRCK.LR.DEF.GPRS	M12720600431		2010-11-01 22:00:26.0	40.26719631	-76.87534433	CLOSED	5.3
TRCK.LR.DEF.GPRS	M12720600431		2010-11-01 20:00:09.0	39.01868159	-76.96608883	CLOSED	1.9
TRCK.LR.DEF.GPRS	M12720600431		2010-11-01 18:27:26.0	38.87864881	-77.17478616	CLOSED	2.2
INFO.EPCIS.QU.ADD	M12720600431	32	2010-11-01 17:21:56.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	30	2010-11-01 17:21:56.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	36	2010-11-01 17:21:56.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	657615	2010-11-01 17:21:56.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	483870	2010-11-01 17:21:56.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	5	2010-11-01 17:21:56.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	731064	2010-11-01 17:21:56.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	491026	2010-11-01 17:21:56.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	12	2010-11-01 17:21:56.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	468705	2010-11-01 17:21:56.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	13	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	11	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	16	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	2	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	7	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	656600	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	491466	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	33	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	731715	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	731609	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	39	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	38	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	15	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
INFO.EPCIS.QU.ADD	M12720600431	731068	2010-11-01 17:21:55.0	38.87908869	-77.1747647	CLOSED	1.8
TRCK.LR.DOOR.GPRS	M12720600431		2010-11-01 17:21:39.0	38.87894922	-77.1750222	CLOSED	1.8
TRCK.LR.BOOT.GPRS	M12720600431		2010-11-01 17:20:04.0	38.87894922	-77.1750222	OPEN	99.9

Loading Events from Information Management Bureau Log for the RFID tagged cargo.

CROSS-DOCKING RE-ASSOCIATION

When cross-docking occurred in Denver the two 53' containers were approximately eight feet from each other at right angles on the corner of the warehouse loading dock. There were significant opportunities for RFI. As the cargo from the containers was switched and both container doors were closed the AMU's successfully reported to the IMB and indicated the re-association of the RFID tags with the current and proximate AMU. See cross-docking screen prints from the IMB in attachment. This was not reported in real time but was delayed until the normal one hour reporting cycle was initiated. In future applications, reporting at the dock or in a specific geozone may trigger an instant report much the same way the alarm cycle does now for such things as door openings or other condition related sensors.

SITUATIONAL CONTEXT

Several benefits of this technical capability were seen during the transit phase. The PACER third party logistics service provider noted through their dispatchers the ability to know the location and status of the cargo as much as 36 hours ahead of the current nodal reporting they receive through existing channels. This was especially the case when routing through known logistics bottlenecks such as the Chicago region. Also, the ability to correlate overhead imagery with plotted map location like Google or Bing provides a context which enables the dispatchers to anticipate or pre-empt some situations. This situational context will provide trustworthiness to the implementation of "virtual" warehousing and enable the transportation system to become a transit storage and delivery system which could ultimately reduce much of the fixed, intermediate infrastructure of the current system.

DOCUMENT CENTRALITY

By bringing the information surrounding a shipment to one or two internet pages which support its time and location along with photos and documentation (e.g., photos of load and unload, images of bills of lading, customs docs and now product descriptions of individual SKU's, the ease of use of the system becomes more obvious. One of the central issues of the demo was to determine if the new data was useful. If it is centralized with other information in the IMB it becomes supportive. If it requires separate access it become a too out of the box.

QUESTIONS ARISING FROM DEMO

- Why there were more reports from RFID tags then were placed in containers?
  -Phantom tag reads.
  -Tags were read multiple times (i.e., they went 'in/out' of range even though they were just sitting in the container).

- Why weren't all of the RFID tags that were reporting to our system not being displayed on the ITI webpage?
  -If they were not in the ITI page, it means at the instant someone was looking at the report, the missing tags were not showing up. The ITI "container portlet" is a real time snapshot. In order to see the drops/adds, you have to look at the tracking log.

- Why did one hour reporting drain AMU batteries before trip completion? (Nebraska outbound; Chicago inbound) Less than 10 day transit time.
  -One hour reports didn't drain the battery. The fact that the unit was always waking up for added/dropped tags caused it to be on longer than expected.

- How can we know when various custody managers have taken physical control of the container? (Pacer, local drayage, CSX, UP, etc)
  I'm not sure there will be anyway to tell on the IMB, unless we know the location of each custody manager's facility and can correlate lat/lon to the custody manager.

- How can we increase the accuracy of the AMU so that a yard manager can know with greater accuracy where the container is?
  The best we can do is 3D GPS fix. Which should be less than 10 meters.

- When a user wants to know where all the "red sweaters" are within a 100 mile radius if they are an LCL or LTL how can we display the information to them?
  We would need to configure some business logic to incorporate documents containing the red sweater packing list (or RFID tags associated with them). Then we would need to create a report that accumulates the totals by geofenced location. This was not configured in the ITI space in the demo.

EXTRAPOLATIONS

- In order to validate the virtual warehousing concept for large scale applications several adaptations will need to occur within the transportation community. One is that the provisioning and control process must become more intrusive and capable of stepping in to change or modify routes and conditions. At least since the Renaissance, the cost of risk has been built into the system of moving cargo from one point to another.. As the statistical concept of loss was developed from the coffee klaches in Amsterdam to the insurance companies in London, the movement of goods could become less impacted by thievery and acts of God. As we begin to take control of what used to be the invisible parts of the system we also need to develop the control mechanisms for active awareness and participation in the movement and reallocation of cargo.

- From a technical standpoint, databases like the IMB will become more relational and reactive and maybe even predictive, in order to support the additional information that managers and “in the trench” dispatchers will need to handle.

FUTURE ENDEAVORS

GlobalTrak and ITI/NCIT are currently discussing several possible extensions of this demonstration. Some possible applications include:

1. The tracking of LCL or LTL from manufacturing site to end-user.
2. The measurement of time saving provided by knowledge of cargo location on an hourly basis.
3. An analysis of Return on Investment for one of the ITI association members using LCL/LTL tracking methodologies.
4. The tracking of various “Just-in-Time” components for coordinated deliveries to the manufacturer.

LIST OF PARTICIPANTS

University of Denver – Intermodal Transportation Institute
System Planning Corporation – GlobalTrak
US. Department of Transportation
PACER-3PL
CSX Intermodal
Union Pacific Stack Trains
Denver Hub Loading Dock
Megaburst, Inc.

CREDITS

Dr. Patrick Sherry-University of Denver/ITI
Briana Hedman – University of Denver/ITI
Rocque Kramer – GlobalTrak, Systems Planning Corporation
Dan Chuhay - GlobalTrak, Systems Engineer
Karen Owsowitz – GlobalTrak, Business Development
Kevin Kleinheinz—Pacer, 3PL
Mike Kellerer, USA-BG(ret), Pacer consultant

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PACER
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RAILEX
STOWE CONTAINER
TRANSSYSTEMS
TTX
UNION PACIFIC
US Department of Transportation

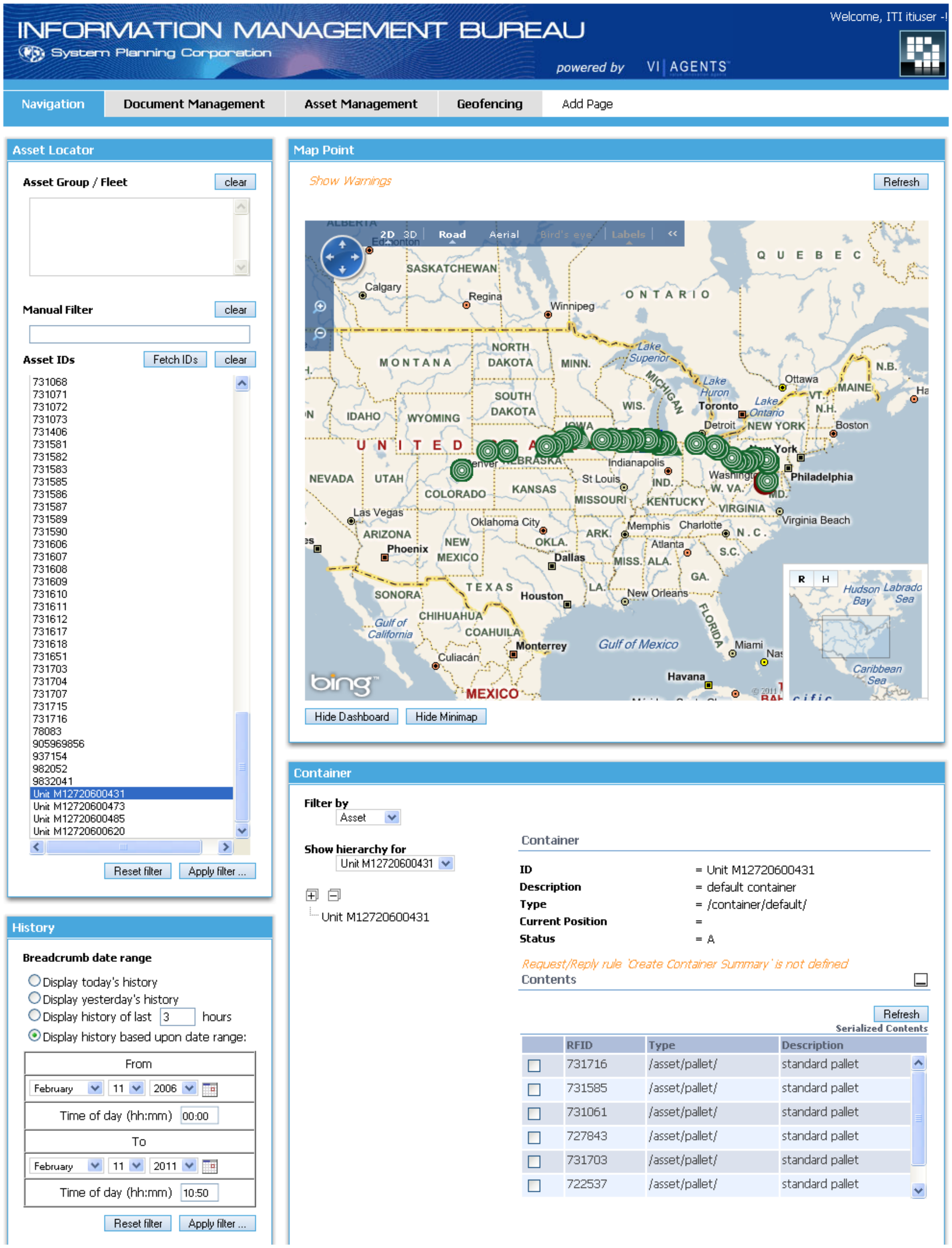
CONTACTS FOR DISCUSSION

Dr. Patrick Sherry, psherry@du.edu

Rocque Kramer, rkramer@sysplan.com

REFERENCE MATERIAL/ATTACHMENTS

1. GlobalTrak System Description PPT.
2. GlobalTrak ROI model.
3. Department of Defense Asset ID Technology Concept of Operations.
4. RFID reporting formats and raw data.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Apply filter ...
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Breadcrumb date range
Display today's history
Display yesterday's history
Display history of last 3 hours
Display history based upon date range:
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Time of day (hh:mm) 00:00
To
February 11 2011
Time of day (hh:mm) 10:50
Reset filter
Apply filter ...
Map Point
Show Warnings
Refresh
2D 3D Road Aerial Bird's eye Labels
bing
Hide Dashboard
Hide Minimap
Container
Filter by
Asset
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