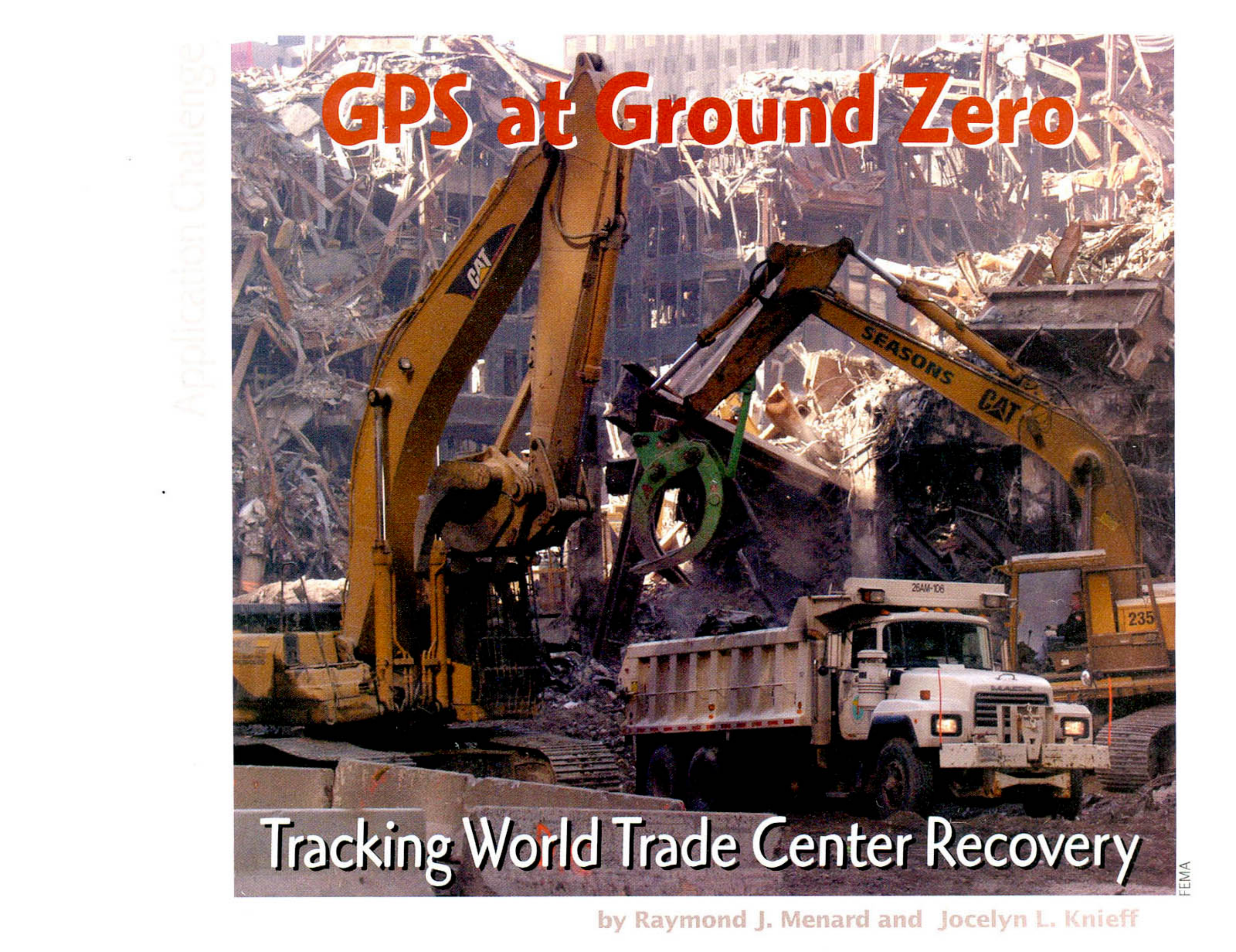

GPS at Ground Zero

Tracking World Trade Center Recovery

by Raymond J. Menard and Jocelyn Knieff

The New York City Department of Design and Construction employed GPS technology in the 8-month, 1.8-million ton cleanup of the World Trade Center site, the first time GPS-based automatic vehicle location has managed debris removal in a disaster recovery setting. Integrating real-time positioning with a communications network, camera monitoring, and internet data access, the system increased efficiency while reducing costs.

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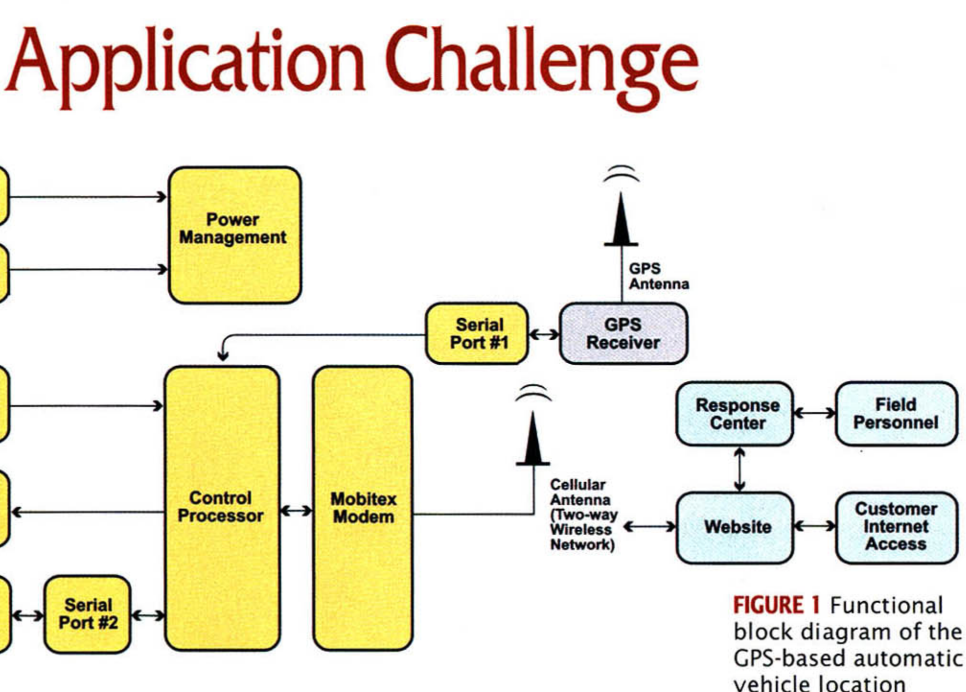

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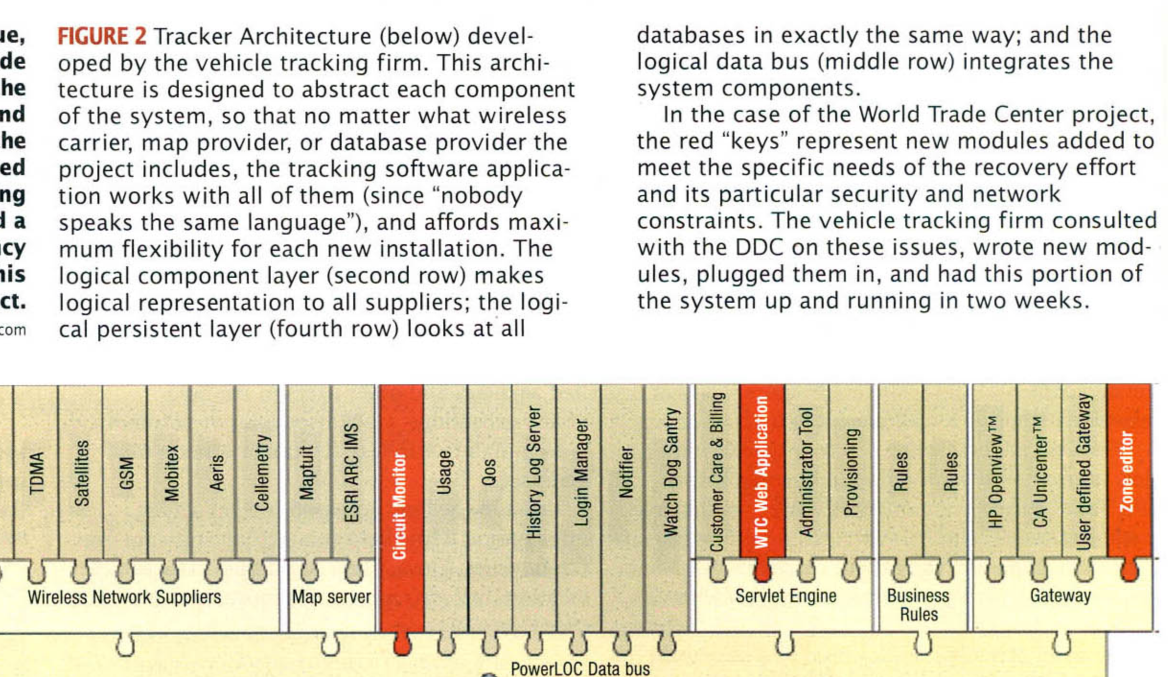

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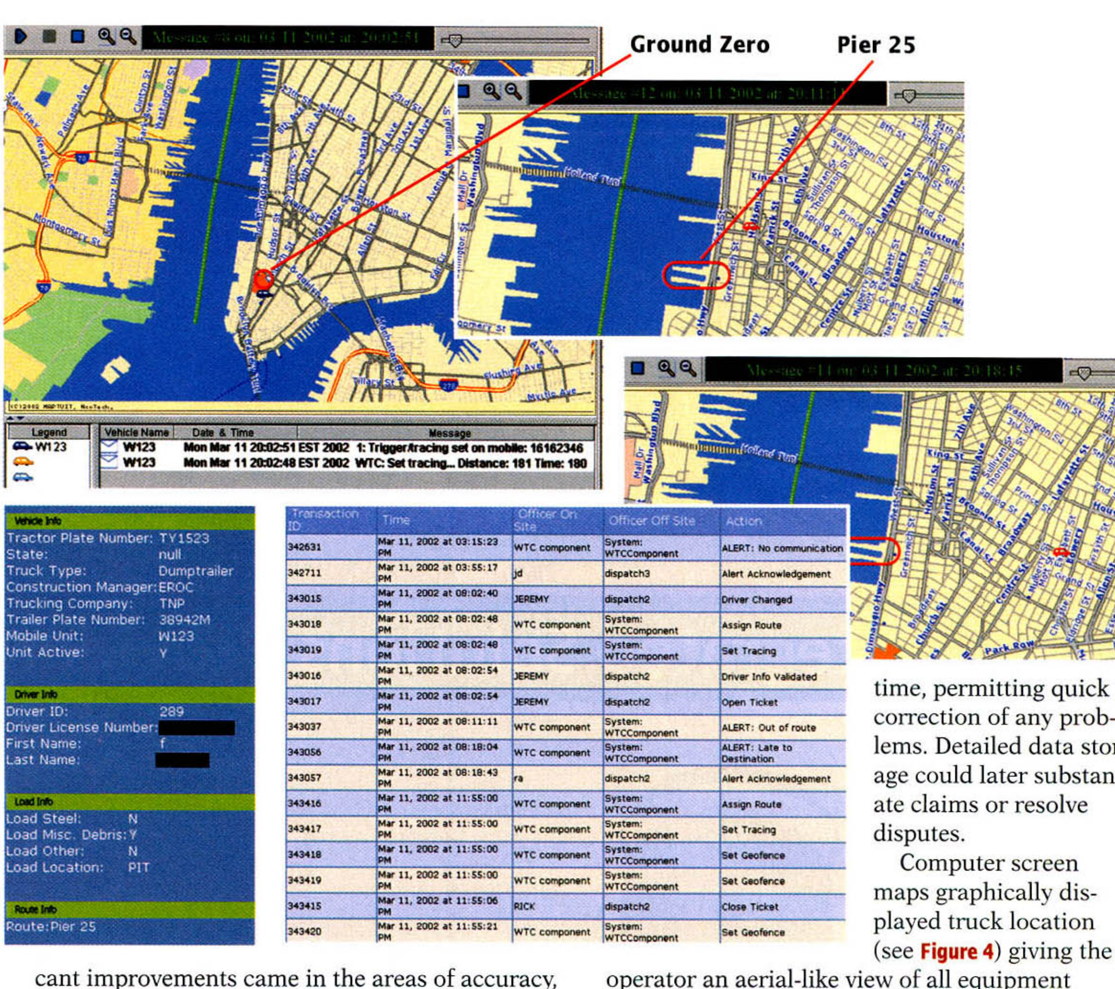

FIGURE 4 Data entry (lower left), reports (lower right), and map displays available through the system

The maps depicts an incident where a driver opened a ticket for Pier 25, but then bypassed the scheduled stop and turned east through Lower Manhattan toward Queens. The geofence breakout turned the onscreen vehicle icon from blue to red and generated an alarm at the response center, which reported the incident to the Department of Investigations for review.

cant improvements came in the areas of accuracy, accessibility of real-time information, and multiple agency access to the data. Because of data accessibility and accuracy, agencies that had performed their own audits discontinued their efforts and relied exclusively on the system data. The number of auditors was cut in half as well.

Increased Efficiency

Handling more than two hundred trucks from multiple contractors delivering loads to five different dumpsites makes inefficiencies — particularly time sitting in queues — hard to avoid. In addition, frequent breakdowns in construction equipment at the WTC site caused loading delays, and when searchers found remains, all onsite work stopped — sometimes for hours.

Also, infrastructure damage around the site created huge bottlenecks and other traffic problems. Prior to AVL system installation, schedulers could not predict or plan on a standard interval for a truck to reach the site, load, leave, and arrive at a dump site.

The GPS-based AVL system enabled staff to locate each truck as it loaded materials at the site and transported them to disposal sites, or to several locations where the loads were transferred to barges for shipment to the Staten Island disposal site, or to metal recyclers in the area. The Web-based system provided information in near real-time, permitting quick correction of any problems. Detailed data storage could later substantiate claims or resolve disputes.

Computer screen maps graphically displayed truck location (see **Figure 4**) giving the operator an aerial-like view of all equipment status at any moment. Complete available truck status included time in, time out, loaded or unloaded, type of load, destination, vehicle speed, name of driver, whether the trailer had been disconnected from the tractor at any time, and similar information. The system could calculate the time any truck spent in queue, improving efficiency and optimizing the number of trucks and other equipment used.

Efficiency Soared. The number of loads per truck more than doubled within days of unit installation. Eventually they rose from approximately three loads per truck per shift to daily averages of more than ten, sometimes as high as fifteen loads per shift.

Further, the response center became the hub of information that could be used in many ways. As site managers' confidence in data and accuracy increased, the DDC granted the response center more authority to manage trucking operations on a minute-to-minute basis.

Using real-time micro- and macro-traffic information, operators sped the process, removed bottlenecks, and placed debris removal resources where they were needed at the right time. Controllers could identify traffic jams in near real-time and re-route trucks to avoid delays.

The system exceeded expectations in management efficiency, security and protection, interoper-

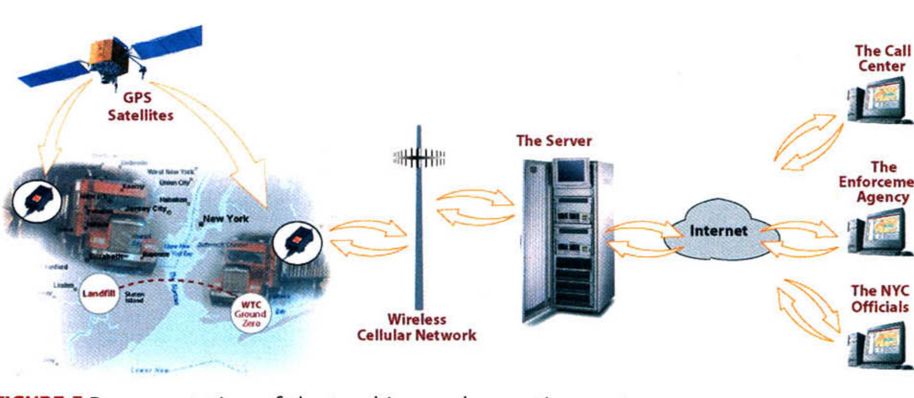

FIGURE 5 Representation of the tracking and reporting system

FIGURE 6 The tracker escalates alerts using e-mail. The user decides where the e-mail should be sent based on the alert raised.

Alert Type	Sent When
No Communication	The tracker is unable to communicate with the vehicle.
Geofence Violation	The vehicle moves out of the route boundaries.
Late to Destination	Vehicle should be at dumpsite but is not there yet.
Trailer Disconnect	The trailer is disconnected from the vehicle.
No GPS Location	The vehicle is unable to report GPS reading.
Tamper	Indicates power-disconnect or case opened.

ability, Internet accessibility, use of commercial equipment, open database, and hardware design specifications. (See **Figure 5**.)

Safety and Security

Early reports at the site hinted at another reason to implement a near real-time tracking solution. The system helped foil looters or those who might seek to sell remnants from the disaster.

Roads Not Taken. To address the issue of potential load tampering, we explored several ideas for added load verification. The team quickly rejected using truck scales to weigh each truck at Ground Zero and again at the dumpsites, because much of the debris was still burning, months after the tragedy. As a result, fire hoses sprayed loads before they headed to the dumpsites, adding water weight and altering actual truck and load weights.

Another proposed load verification method used a digital photo management system of time-lapse cameras to photograph the loads before leaving Ground Zero and again upon reaching the dumpsite, visually inspecting the hauled debris. The DDC elected not to adopt this option because of cost, timeline urgency, and, most crucial, while wash stations had to be mobile, the photo management equipment required rigid heavy-duty structures that couldn't easily move.

GPS Shows the Way. Instead, we found safeguards to prevent load-tampering, hijacking, re-directed loads, unauthorized dumping or worse, and dumping and co-mingling of off-site hazardous materials, in the GPS-based vehicle tracking system itself (see **Figure 6**). These safeguards included geo-fencing, the near real-time tracking capability, and tamper alarms.

An electronic "geofence" alerted the monitor any time a truck strayed off the approved route. When trucks broke the pre-set geofences, recorded signals showed location information as well as arrival and departure times. A replay feature could then provide an animated re-creation of the exact route any truck took at any point in the operation. The sequence in Figure 4 depicts an example of an incident where a driver opened a ticket to Pier 25, then bypassed it and went out to Queens, New York. The response center recorded the history and turned it over to the Department of Investigations for review.

Tunnel Geofencing. Since some hauling routes went through tunnels, the AVL system provider scripted a special geo-fence before and after the tunnels. When a vehicle approached a tunnel, the system sent a message to the tracker, informing it of the approaching tunnel. The tracker then lowered the tracking levels for a set period of time. When the vehicle exited the tunnel geo-fence, the system re-set the tracking level to the old defaults. This feature, implemented specifically for the WTC project, required exact definition of route and tunnels.

The system enhanced security of crime scene evidence and of certain high-value materials through intensive near real-time tracking: if something started to happen, the response center could spot it and stop it. Although hard to measure, the savings delivered through security-based cost containment prevented significant incidents from developing once the system was implemented.

Looking Back

A national terrorist attack obviously creates a drastic situation, requiring immediate response. The New York City DDC deployed GPS-based technology to manage, for the very first time, debris removal in a disaster-recovery setting, with remarkable results.

The system provided a near real-time view, including graphically mapped presentations, of trucking operation on a macro level, including disaster area, routes, and dumpsite locations. Operators proactively routed trucks around bottlenecks and to alternate dumpsites based upon queue times.

Most notably, the response center became the information hub for agencies, operators, and all onsite users. Everyone gravitated there for quickly provided data essential to operations.

The system furnished historical reports on daily and even hourly activity, based on variables including driver, trucking company, debris type, route traveled, dumpsite, and others. Up-to-the-minute data enabled viewing on-screen the route a truck drove during its shift.

The team implemented the entire project for

FIGURE 7 WTC project timeline

10/15/01 Received request for proposal with 48 hours to respond
10/17/01 Submitted proposal
10/26/02 Proposal accepted
10/31/01 Team began work at WTC site
11/07/01 First vehicles online, communications network operational
11/21/01 All vehicle units installed and functional
11/27/01 Fiberoptic network turned on
12/05/01 On-site response center went live
06/28/02 Work complete — officially shut down systems (audit data and digital photos remain on-line)

less than the cost of the previous paper ticket system. In addition, the system collected more data, more accurately than the paper ticket system, making it available for reports as well as field use the moment it was collected.

Overall, replacement of the paper ticketing alone paid for the entire cost for ticketing, traffic management (including GPS hardware), load and operator security, and assembly of audit data.

The system significantly enhanced security, enabling immediate dispatch of agencies to investigate errant loads, unauthorized loads at dumpsites, and other issues.

Audits. The extensive reporting and enhanced security improved audit and monitoring processes while significantly reducing the requirement for audit personnel. The DDC estimated that more than 50 percent of the audit staffing requirement was eliminated — more staff than the Criticom team needed to run the entire operation.

Increasing the efficiency of the trucking operation, more than tripling the number of loads per truck per shift, reduced the number of trucks needed, again saving money and accelerating the clean-up operation.

Overall, a removal project initially estimated by city officials at $7 billion actually came to just $750 million.

Timeline. In the first six months, trucks and tugs removed more than 80 percent of the debris, and in June 2002, the effort drew to a close, at least four months sooner than originally predicted.

On May 28, 2002, hundreds of construction workers at Ground Zero watched the removal of the last steel beam left standing at the demolished World Trade Center, an act marking the end of an overwhelming and heroic recovery effort.

Some system work continued until June 28, tracking trucks to Staten Island. The confidence in the GPS system allowed DDC to shut down Pier 25, which was costing almost $100,000/day to operate. Even after June 28, system data has been kept live and available to all participating agencies for rigorous audits of the entire project. (See **Figure 7**.)

At Criticom, we feel that working on this project was a great honor. We are grateful to have contributed to the recovery effort.

Looking Ahead

Encouraged by the success of the GPS-based management and tracking solution, the City of New York, FEMA, and other state and federal agencies have expressed their intent to incorporate this technology into future recovery efforts following such natural disasters as earthquakes, floods, and hurricanes.

The GPS tracking system allows government agencies to be more flexible and responsive by using a cost-effective time-and-materials system. Most of the trucking companies involved in the recovery effort experienced firsthand the effectiveness of the GPS management system and are interested in purchasing the units and systems to improve efficiency and management of their own commercial fleets as well.

Deploying a new technology in a new situation always presents significant challenges. In the WTC recovery effort, the disaster surrounding the project compounded its complexity and difficulties. The DDC's selection and application of GPS and other advanced technologies paid significant dividends and may be deployed in future disaster situations. Understanding gained through the WTC recovery will be invaluable in future recovery applications. ⊕

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Manufacturers

Criticom International Corporation (Minneapolis, Minnesota) developed and coordinated the WTC project, providing a broadband communications network, Internet services, and on-site staffing to manage the systems. Criticom provides emergency and non-emergency monitoring services for fixed and mobile assets, maintains nationwide licensing, Public Safety Answering Point (PSAP) database information, and multiple 24/7 redundant monitoring locations to provide GPS location-based emergency monitoring services to manufacturers, fleets, government, and other customers.

PowerLOC, a division of **Paradigm Advanced Technologies Inc.** (Richmond Hill, Ontario, Canada), developed the WTC software application on its Tracker Server and furnished a custom vehicle location device based on its *VLD 103* product line, utilizing the *SiRFStarI* receiver and RIM Mobitex wireless technologies.

Mobile Installing Technologies installed the equipment in the trucks and tugboats.

Time Warner, Inc. donated over $75,000 worth of equipment to provide the T1 service onsite.

The communications system used the *Mobitex* network developed by **Motorola** and deployed in the New York City area by **Cingular Wireless**.

Lynx PM provided digital photography management software for images taken and stored, though not fully integrated into the system.