Rapidly Recovering from the Catastrophic Loss of a Major Telecommunications Office

Kelly T. Morrison, AT&T

ABSTRACT

Ready access to communications networks has become a necessity for nearly every type of organization (business, non-profit, government) and for individual users. If a catastrophic disaster destroyed a city's central network office, telecommunications users in that region would lose their network connectivity — data, voice, cellular — until the office's capabilities could be restored. That isolation could put lives and livelihoods at risk as an affected city tried to respond to a large natural or man-made disaster. AT&T has a mature network emergency management and business continuity program that plans for and responds to events that affect the AT&T network and its support systems around the globe. Within that NEM plan, the AT&T Network Disaster Recovery team is responsible for the restoration of a failed network office's services. This article will describe NDR's mobile response process and how it fits within AT&T's overall response to a disaster.

INTRODUCTION

A large telecom central office is the nexus for the communications services for an entire city or region; it manages special services (911, video, etc.), routes traffic within a community and moves data on and off the global fiber network. A central network office contains equipment that supports a broad array of services-from simple, twisted-pair residential dial tone to cellular traffic to high-speed, multi-spectrum IP data.

Together, the various telecom technologies form a large, complex machine that typically spans several floors of a dedicated building. Each network office (central office) has a unique profile based on the equipment installed in the building and on the services that are provided to its region.

The central office buildings are robust. Oscillations from the 6.7 M_w Northridge, California, earthquake in 1994 damaged the walls of AT&T's Sherman Oaks office, but operations continued and the building was declared safe. Network offices in flood plains and along the hurricane coasts are elevated or use lower floors for administrative space. All of the central offices have redundant power sources — commercial feeds from local utilities, back-up generators with dedicated fuel supplies, and large battery strings that provide the equipment with uninterrupted power.

AT&T's network architecture and network management practices minimize the potential for outages to affect its customers. Diverse network paths and automated rerouting provide nearly instantaneous responses to cable cuts or congestion. Network management becomes even more proactive in advance of known events, such as approaching hurricanes or large civic or sports events, when traffic is rerouted away from parts of the network that may be impacted. It's an effective system — AT&T's global network moves over 20 petabytes of data a day with a 99.99+ percent reliability rating.

But the "what if" question remains. What could be done if a large network office was completely destroyed? Traffic management and rerouting could do nothing to restore network access to the community and to the businesses directly served by that failed office. Normal communications services could not be reestablished until the capabilities of the central network office were restored. A traditional brick-and-mortar restoration could take months or longer — an unacceptably long period that would leave an area ill-equipped to recover from a disaster.

PLANNING FOR THE WORST: CATASTROPHIC DISASTER RESPONSE

AT&T's Network Disaster Recovery program was formed in 1991 to develop a way to respond to that "what if" scenario — the loss of an entire central office. The NDR solution combines network infrastructure and support trailers, recovery engineering software applications, and a response team with both full-time and volunteer members from AT&T. The trailers provide the physical components that carry the restored network traffic. The software platforms allow those components to take on the services of the failed building. The team members create, connect, turn up, and manage the recovery complex (Fig. 1).

0163-6804/11/$25.00 © 2011 IEEE

NDR Recovery Trailer Fleet

Each NDR technology trailer contains a telecom infrastructure element that is present in a normal AT&T central office. Installing, configuring and testing the equipment in advance eliminates the delay of having *first-off-the-line* equipment sent from vendors after an office has been lost, and it also eliminates the need to find a suitable replacement building in an area devastated by a disaster. The recovery trailers allow the equipment to arrive at a stricken city ready for service, in powered containers that, when interconnected, serve as a temporary network office (Fig. 2).

The equipment is installed in bays/racks down each side of the trailer, leaving a working aisle down the center — like the layout of equipment bays in a permanent office. The equipment is powered by battery, through a rectifier, and the batteries are constantly charged from commercial power, from a large portable generator (e.g., 600kW) or from a dedicated generator (usually built in to the front of each trailer). Fiber-optic and/or copper-T3 cabling connections to the equipment are made in internal and/or external cabling bulkheads on each trailer.

The technologies present in the trailers have evolved since the early 1990s following the changes in the AT&T network. The trailers now include IP and OC-768 (40 Gb/s) fiber-optic *transport* systems that support the high volume of data that traverses the AT&T network. The IP trailers, when fully-equipped, can scale up to a capacity of over 10,000 T3s. The technology fleet includes ATM, Frame Relay, DMS, and 5E switch trailers, and lower speed fiber transport and Digital Access Cross-Connect Systems (DACS) trailers to allow intercity/intra-city services and interfaces between the network's copper and fiber-optic infrastructure.

Figure 1. *NDR exercise in Washington, DC, in July 2009.*

AT&T's AGN network in the global markets is supported with disaster recovery trailers staged in both the United States and in Europe. Some of the AGN equipment is installed in fly-away containers that can be shipped by commercial air carrier. Following the earthquakes in Chile in February 2010, AGN recovery nodes were flown to Santiago and set up near a permanent telco office in case aftershocks made that building, and its equipment, unusable (Fig. 3).

NDR's recovery equipment is maintained

Figure 2. *NDR technology recovery trailers.*

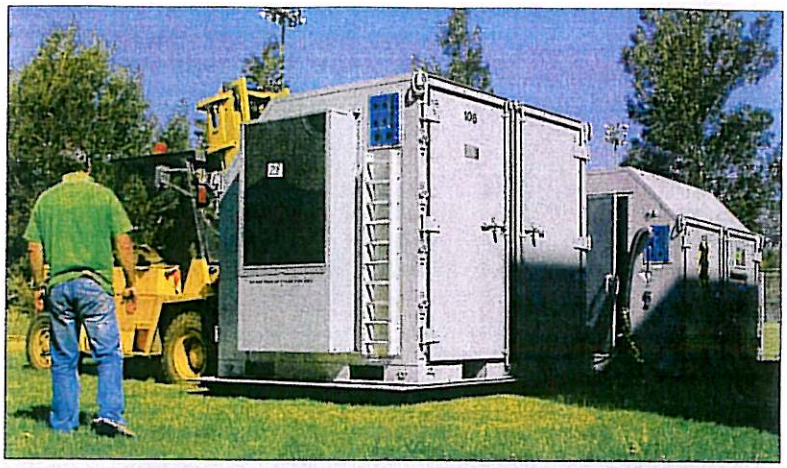

Figure 3. *NDR AGN recovery nodes in Santiago, Chile. March 2010.*

in warehouses across the United States and in Europe — positioned strategically so the equipment can reach AT&T's network offices quickly. The equipment doesn't sit idle. It is kept powered up and on-network so updates can be installed and so it can be tested both on-site and remotely. NDR's warehouse teams are responsible for the health and welfare of the equipment inside the trailers and for the running gear that lets the equipment travel. It's a unique blend of skills that crosses the spectrum of tasks from machining parts to configuring core network routers.

In 2010, the eighty-sixth recovery technology trailer was added to the fleet. NDR's total inventory includes over 350 pieces of equipment, including large power and support trailers, emergency communications vehicles, hazmat trailers, and escort vehicles.

NDR Emergency Communications

NDR's deployment plan includes an assumption that no normal communications channels will be available when the team arrives at a recovery site in a disaster area. The team establishes *first-in* communications capabilities using an emergency communications vehicle (ECV). The ECVs are four-wheel drive vans or SUVs that use a satellite link to provide broadband LAN, Wi-Fi, and voice (VoIP) connectivity for the team at a recovery site. The ability to set up a small footprint of cellular coverage using a microcell was added to the ECVs in 2010. The ECVs can be set up rapidly (15–20 minutes) and are self-sufficient — they have dedicated generators and tow support supplies in a small trailer. The ECV data/voice feed is connected to a router and to a PBX to distribute LAN connectivity and dial-tone to each trailer on the recovery site (Fig. 4).

Because of their rapid response capability, the ECVs have been frequently deployed to provide emergency communications capabilities for other responders or to provide service at intake centers for disaster victims. AT&T deployed four ECVs and a fly-away satellite unit during its Hurricane Katrina response in 2005 and used ECVs as recently as May 2010 to provide Wi-Fi service for flood victims in Nashville, Tennessee.

The team can also use 5.8 GHz microwave radio links to rapidly establish communications channels from a disaster area back to a functioning AT&T network office or point of presence (POP). NDR practices setting up these links during exercises and uses the capability to remotely monitor the trailers and to provide higher capacity data service for the site. These

Figure 4. *Emergency communications vehicle and microcell at NDR's exercise in San Jose, California, July 2010.*

temporary microwave radio links were used to recover service in 2008 after damage from Hurricane Ike isolated some of the cell towers on Galveston Island. They were used for the same purpose after Nashville's flooding in May 2010.

Recovering a disaster area's cellular communications requires a functional central office and the ability to restore the capabilities provided by individual cell sites. A portable cell site — a cell on light truck (COLT) or cell on wheels (COW) — can be used to replace the service provided by a failed site. Cellular antennas are attached to a pneumatic mast on the COLT or COW and connected to the same backhaul network feed that served the permanent site. COLTs and COWs are also frequently used in business as usual conditions to augment existing service to an area during large-scale events, such as civic or sporting events.

If backhaul facilities have also been destroyed or are not available, the data from the temporary cell site can be passed back to the AT&T network with a satellite link. NDR's satellite COLTs were used on Galveston Island to reestablish cellular communications for first responders after Hurricane Ike's landfall in September 2008. The satellite COLTs can be configured to provide controlled network access to specific devices preventing oversubscription to a COLT's service.

Like the ECVs, the Satellite COLTs have been used frequently to provide emergency communications capabilities for first responders in areas that don't normally have cellular coverage. Two of NDR's satellite COLTs were deployed to Arkansas in June 2010 after a flash flood washed campers away near Caddo Gap; a satellite COLT provided additional cellular coverage in Montcoal, West Virginia, after the coal mine explosion in February 2010 (Fig. 5).

Figure 5. *NDR Satellite COLT at an exercise in San Diego, CA, in October 2010.*

Recovery Engineering

The NDR strategy demands the ability to reengineer — quickly — a permanent office using the technology trailers as the puzzle pieces. When the team is activated, the NDR recovery application is initiated; it polls the network office records and assembles an inventory of the lost equipment, the services the failed office supported and the configuration profiles of the office's systems. The NDR engineering team uses the data to build a list of technology trailers that will be necessary to recover the capability of the failed or destroyed office. This first step happens rapidly, allowing the NDR warehouse teams to get the correct set of technology trailers on the road to the recovery location.

The NDR engineering team will begin creating a cabling plan that will allow the individual technology components in the trailers to work together as the recovered network office. The trailers pass data between one another through fiber-optic and/or electrical DS3 cables that are connected to particular ports in bulkhead panels on each trailer. A large office recovery complex could include over 10,000 individual T3 and optical bulkhead connections.

The assignments for the connections are unique — allowing the NDR equipment to be configured to restore the services of the lost office. Those assignments are made using a software application developed for and by the team since the early 1990s. The latest release of the engineering platform, called RUBY, was issued in late 2009. The cabling plan is developed while the equipment is on the road and being set up at a recovery site. The plan is downloaded at the recovery location over temporary satellite or digital radio network links.

Recovery Operations Team

NDR has a permanent staff assigned to day-to-day operations (equipment, engineering, incident management, emergency communications, hazmat) and a roster of other AT&T employees who volunteer to work on the team during training exercises and deployments. A subset of the team is trained as hazardous materials technicians who can work in areas that have been contaminated by CBRN hazards (see hazmat sidebar). All Operations Team members receive training that prepares them to build a recovery site with NDR's specialized equipment and to perform that task in challenging conditions.

The roles of most of the team members evolve throughout a disaster response. In the early phase of the effort, they will be assigned to construction crews as the equipment is brought on to a recovery site, grounded, and connected with power and communications cables. They regroup into technology teams turning up the equipment trailers and preparing the recovery complex to begin acting in place of the failed office.

Each of NDR's three components — the equipment, the engineering system, and the trained team — is essential to perform a rapid network office recovery. AT&T has invested more than half a billion dollars in the program since 1991, but that would provide little meaning if the capability wasn't tested. From its inception, field testing has been an integral part of the NDR program.

Figure 6. *NDR exercise in Dearborn, Michigan, in May 2010.*

Testing on Pavement (Not Just on Paper)

The NDR team held its first recovery exercise in early 1993 near Atlanta, Georgia, and completed its 59th field exercise in October 2010 in Philadelphia, Pennsylvania. The NDR drills are used to validate and refine the recovery processes, to train team members and to work with new recovery equipment as it comes into the trailer fleet. The exercises also give the NDR members opportunities to work with local emergency management agencies.

An NDR exercise is usually held on an open parking lot, but exercises have been held on city streets (Phoenix, Arizona), vacant urban land (St. Louis, Missouri), and open fields (Arlington, Virginia). And the drills have been held in a variety of weather conditions: 100° F heat (Denver, Colorado), 95° F heat plus humidity (Arlington and Tampa, Florida), and 24 inches of snow (Salt Lake City, Utah). Working through real-world variables keeps the team prepared for a response in any location at any time of the year (Fig. 6).

One or two days before an exercise, NDR team members escort the recovery equipment convoys from the warehouses to a staging area near the recovery location. Over the course of the next two to five days, an empty lot is transformed into a modern telecommunications network office, replicating the same steps that would be used in an actual response.

Throughout each drill, metrics and issues are logged by team leaders and by the incident management team (see Incident Management sidebar). A standards team reviews issues after each drill or deployment and documents their resolution. This quality cycle has been a key feature in the program's development — eliminating predictable problems, highlighting training needs, and fine-tuning the recovery processes.

Putting the Puzzle Together

When the decision is made to deploy equipment, the trailers are powered down and prepared for travel while the semi-tractors are dispatched to the warehouse(s). (For a large central office recovery, equipment could be deployed from two or three warehouses, putting thirty or forty trailers on the road.) The warehouse teams escort the equipment to the recovery site, protecting AT&T's investment while it is on the highway. Once on site, the escort crews take on roles on the recovery operations team.

An ideal recovery location would be adjacent to a failed office because it would allow the easiest access to the fiber-optic cables that served that office — the recovery complex will eventually be spliced into those cables. But local conditions may prohibit that convenience and the recovery site may be some distance from the original office. (NDR's World Trade Center recovery site was established in New Jersey in September 2001, directly across the Hudson River from lower Manhattan; the trailer complex was spliced into the fiber optic ring that had served the destroyed office.)

Once a suitable recovery site is secured, the NDR operations team begins its phase of the recovery process. The trailers are brought onto the site following an engineered plan that assures that all of the equipment can be joined together with both communications and power cables. The construction phase — trailer positioning, leveling, grounding, and cabling — can last several shifts with sixty or more NDR members working in small teams.

As cabling is completed, the trailers are powered up and NDR SMEs turn the equipment on — booting up the recovery complex. After the equipment comes online, it is configured to take on as many of the capabilities of the lost office as possible. The recovery site will first be used to establish through-service on the network, and then services providing access to the community will be added. In the United States, telecommunications carriers must follow the recovery priorities provided by the federal government's Telecommunications Service Priority program.

As conditions in the impacted city normalize and the local AT&T workforce is prepared to return to work, responsibility for the recovery site would be transferred to the local teams. The NDR equipment would remain in place until the failed office's services are restored in permanent buildings.

NDR Deployments: September 11, 2001

The Network Disaster Recovery team's largest deployment was in response to the World Trade Center disaster in September 2001. A small local network switching office in a building adjacent to the WTC was destroyed when the towers collapsed. NDR was deployed to support the recovery of that office's services and to provide emergency communications for the relief work in lower Manhattan.

Equipment began arriving at a staging location in New Jersey at 6:00 a.m. on September 12, 2001. A construction lot in Jersey City, across the Hudson River from the WTC site, was secured as the technology recovery site that afternoon. The team and its equipment were escorted to the site, and the initial site setup was

Figure 7. *NDR WTC recovery site in Jersey City, New Jersey, in September 2001.*

Predictable Management in Unpredictable Settings

NDR manages its events and exercises with a modified version of the Incident Management System (IMS) that is used by government and private sector emergency responders in the United States and around the globe. NDR's model, in use since 2000, was modified for telecommunications needs and to work with the team's recovery practices.

IMS is a role-based management system that scales in size to match the complexity and risk-level of the response. It allows the NDR team to effectively work within AT&T's larger incident management system and to work easily with other responders in a disaster area.

The IMS model places an emphasis on protecting responders' safety and on personnel accountability — a critical element in high-risk areas. Information and assignments are tracked with a web-based incident management application that allows on-site and remote command team members to see and update real-time information.

Sidebar 1. *Incident management.*

completed shortly after midnight on September 13 (Fig. 7).

The site was joined to the same fiber optic ring that had served the destroyed office and began supporting through-service, as the lost office, on September 15. The site remained active until October 24, 2001, after permanent network offices in the area took over the services of the WTC office.

An ECV was deployed to the NYPD's command center in lower Manhattan on September 12 to provide emergency communications. The ECV was moved to the North Cove Yacht Harbor, adjacent to the WTC disaster site, on September 21. It provided free telephone service for the relief workers until October 3, 2001.

NDR Deployments: Galveston Island, September 2008

NDR's deployment to Galveston Island after Hurricane Ike's landfall on September 13, 2008, was the team's first response representing the new, larger AT&T (including the networks of the former AT&T, SBC, BellSouth, and Cingular). While it was not a large activation like the 9/11 response seven years earlier, it did test and demonstrate the team's added responsibilities and capabilities (Fig. 8).

Team members arrived at Galveston's UTMB hospital on September 14 and established cell service with a satellite COLT. The COLT remained in use until September 20, when the permanent cell site on top of the hospital was repaired and brought back on the air. A second satellite COLT was deployed on September 14 to Ball High School in Galveston to provide cellular service for the Texas Department of Public Safety Emergency Operations Center. It was moved to a DPS checkpoint on I-45, north of Galveston Island, on September 21, and remained active until October 1, 2008.

The team set up a command location at an AT&T logistics-staging compound in Pasadena, TX, with five personnel, a small command center and two ECVs. They supported the work being done by other AT&T responders and

Figure 8. *NDR Satellite COLT at UTMB Hospital on Galveston Island, Texas, September 2008.*

Special Operations (Hazardous Materials Response)

NDR formed its Special Operations team in 2002 to provide AT&T with the ability to maintain the telecommunications and support equipment in an office that has been contaminated by chemical, biological, radiological, or nuclear (CBRN) hazards. The team includes over twenty-five NDR members who have completed the training to become hazardous materials technicians and who receive ongoing training each year to maintain their skills and certifications. Twelve members are Telecom Hazmat Specialists (North Carolina Occupational Safety and Health Education and Research Center) and were the first responders to receive this industry certification.

AT&T would activate its NDR Special Operations Team to assess damage to an office (after it was released by governing authorities) that may have been compromised by hazardous materials. The team would perform the initial reconnaissance of the office and then perform maintenance tasks until the contamination was contained or otherwise remediated. The team could also be called upon to salvage critical network infrastructure from a contaminated office.

The team is equipped with self-contained breathing apparatus (SCBAs) and a variety of protective suits, including Level A suits that fully-encapsulate the responder. NDR joins with AT&T's Environmental Health and Safety (EH&S) organization to assure that the team members are well-trained and that they are properly protected during building entries. The EH&S members act as the team's safety officers, write the event's health and safety plan, and are responsible for the ongoing hazard assessment (determining level of risk and level of protection the team will need to use in the contaminated *hot zone*).

Sidebar 2. *Hazmat sidebar.*

repair crews working in Ike's landfall area, helping to increase the speed and capabilities of the local response. In total, the team managed the deployment of five satellite COLTs and one satellite COW from Sugar Land to Galveston Island. The team also provided 24 5.8 GHz microwave radio hops (links) to restore communications from isolated cell sites on Galveston Island and the Bolivar Peninsula to the east.

An additional NDR team was deployed on September 14 to recover the services of a small local network office on Galveston Island that had been inundated by Ike's tidal surge. A technology trailer, a command center, an ECV and a tool/supply trailer arrived at the recovery site (adjacent to the network office) on September 16. Local technicians and network SMEs restored the damaged office's through-service early on September 17. NDR turned the recovery site over to the local workforce on September 18, 2008; the local AT&T staff managed the equipment until the office was fully restored.

The team's Hurricane Ike response included elements from all parts of the new AT&T Network — local, wireless, and core network services.

NDR within AT&T's Network Emergency Management Plan

NDR is only one part of AT&T's overall Network Emergency Management (NEM) plan. The NEM structure includes the AT&T Global Network Operations Center (GNOC), regional emergency operations centers (EOCs), local response centers (LRCs), other first-in teams (damage assessment, power/HVAC, etc.), and logistical, medical, and safety support organizations. All of the organizations report upwards to the GNOC. The GNOC's leadership team is responsible for setting the strategic direction for all of the NEM organizations' activities during a network disaster response.

During a large deployment, NDR would work closely with LRCs and EOCs to obtain logistical support and access assistance from government agencies as the recovery team and its equipment move into a disaster area. For example, special access passes may be required to enter an area under the control of law enforcement agencies. The AT&T EOC staff would be in contact with their peers in government EOCs activated for the response and would be aware of special conditions that could affect the AT&T responders.

Conclusion

AT&T's Network Disaster Recovery program provides the company with a predictable and proven way to respond to the catastrophic loss of a large network office. The capability is built upon a unique inventory of network technology trailers, custom recovery engineering software applications and a well-practiced team of employees trained as telecom disaster responders. The mobilized equipment allows for rapid deployments that are tailored to a particular event's needs. NDR is one of the field teams in AT&T's overall Network Emergency Management program.

Acknowledgments

The author would like to thank the AT&T NDR process managers and GNOC program leaders who participated in the review of this article: Tim Davis, Bob Desiato, Mark Francis, Sandy Lane, Kevan Parker, Steve Poupos, Joe Starnes, Ray Supple, and Gary Watko. The author would also like to thank Chi-Ming Chen, AT&T Labs, for his support of NDR and this article.

Bibliography

[1] FEMA, "About the National Incident Management System (NIMS)"; http://www.fema.gov/emergency/nims/AboutNIMS.shtm

[2] U.S. Department of Homeland Security, "About TSP (Telecommunications Service Priority)"; http://tsp.ncs.gov/about_tsp.html

[3] AT&T, "Business Continuity Preparedness Handbook: A Proactive Approach is Key," July 2010.

[4] C. Kalmanek, S. Misra, and Y. R. Yang, *Guide to Reliable Internet Services and Applications*, Springer, 2008.

[5] M. Buchanan, "Inside AT&T's National Disaster Recovery Batcave: Who AT&T Calls When the Death Star Explodes," Gizmodo, Aug. 2, 2010; http://gizmodo.com/5602414/inside-atts-national-disaster-recovery-bunker-who-att-calls-when-the-death-star-explodes

[6] N. Patel, "On the Ground with AT&T's Network Disaster Recovery Team," Engadget, May 29, 2008; http://www.engadget.com/2008/05/29/on-the-ground-with-atandts-network-disaster-recovery-team/

[7] North Carolina Occupational Safety and Health, "Telecommunications HAZMAT Specialist Certificate"; http://osherc.sph.unc.edu/hst_cert.htm

Biography

Kelly T. Morrison (km4614@att.com) obtained his B.A. (English/history) from Westminster College in Salt Lake City, Utah, in 1983 and pursued graduate coursework in technical journalism at Colorado State University in Fort Collins. He joined AT&T in 1990 and worked in network documentation groups until becoming a full-time member of the AT&T Network Disaster Recovery program in 1998. He serves as public information officer on NDR's incident command team and supports the NDR and Global Network Operations Center web sites. He was deployed for and documented NDR's responses to the F5 tornado in Moore, Oklahoma, in 1999, the 9/11 attack in New York City, Louisiana/Mississippi following Hurricane Katrina's landfall in 2005, and Galveston Island, Texas, following Hurricane Ike's landfall in 2008.

AT&T's Network Disaster Recovery program provides the company with a predictable and proven way to respond to the catastrophic loss of a large network office. The mobilized equipment allows for rapid deployments that are tailored to a particular event's needs.