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REBUILDING THE WORLD TRADE CENTER

The second-tallest building in the world still stands tall despite the heinous actions of fanatics. Here's what happened when the bomb went off and why the rebuilt twin towers are stronger than ever.

(From our July 1

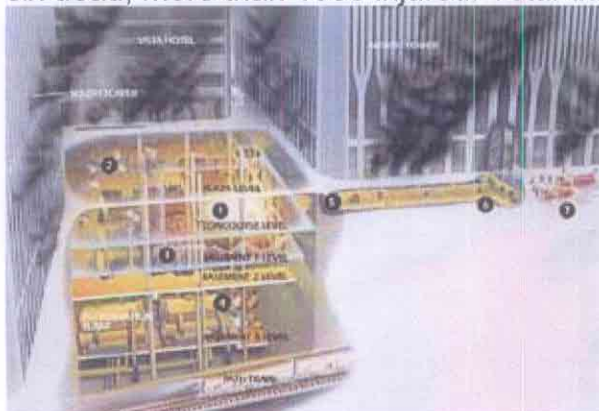
BY HERBERT SHULDINER
Illustration by George Retseck
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Editor's Note □ A few minutes before 9 a.m. on Tuesday, September 11th we watched with horror as a pair of fuel-laden passenger jets crashed into, and brought down, the World Trade Center in New York City. The event that no one believed possible had occurred. Terrorists had attacked American soil. With a population larger than the towns most Americans call home, the twin towers of the World Trade Center were truly a city within a city. As the tragedy of the great structure's demise began to unfold, we were struck by the numerous reports of occupants having escaped from the 80th floor and even higher. Luck had something to do with it, but good structural engineering counted for more. In their last minutes these magnificent buildings remained standing long enough for tens of thousands to safely evacuate. How the towers could sustain the impossible blow of a collision with two heavy airliners was the subject of a July 1993 article, which appeared after the first diabolical terror attack.

Charles Maikish was signing a lease when the bomb exploded. "It felt like there was a slight lifting of the tower, and there was a loud noise," recalls Maikish, director of the 7-building, 16-acre complex known as the World Trade Center. At 12:18 pm, on that raw February 26, Maikish was in his 35th-floor office in the North Tower. Right then, says the FBI, a 1500-pound explosive device, laced with hydrogen tanks as accelerants, detonated in the complex's subterranean parking garage. The blast punched through five underground floors. More than 200 cars, including 50 Secret Service vehicles, were instantly ablaze, releasing caustic, oily smoke. Shockwaves breached walls into the twin towers. The smoke, drawn up by a stack effect in elevator shafts, billowed throughout both 110-story buildings. More than 50,000 employees and thousands of visitors fled, many groping down dozens of flights in pitch-black stairwells, and a 12-hour rescue operation ensued.

The disaster went to 16 alarms □ the most in New York City history □ and summoned 66 fire engines, 52 trucks, five rescue companies and two fireboats. Total casualties: six dead, more than 1000 injured. Total damages: more than a half-billion dollars.



WHAT HAPPENED

1. Van parks on Basement 2 (B2) level. Bomb detonates at 12:18 pm. Blast disintegrates concrete floors of B1 and B2. Crater extends to B5.
2. At least 200 cars are immolated, releasing oily black smoke.
3. Ruptured pipes cut off cooling water to backup generators, killing power for towers' public-address system, lights and smoke-purge fans.
4. Thousands of tons of rubble and water crush refrigeration plant for air-conditioning system.
5. Explosion shatters concrete wall, allowing smoke to penetrate tower. Blast breaches elevator-shaft wall.
6. Smoke races up shafts and spreads throughout towers.
7. Fire units begin arriving at scene.

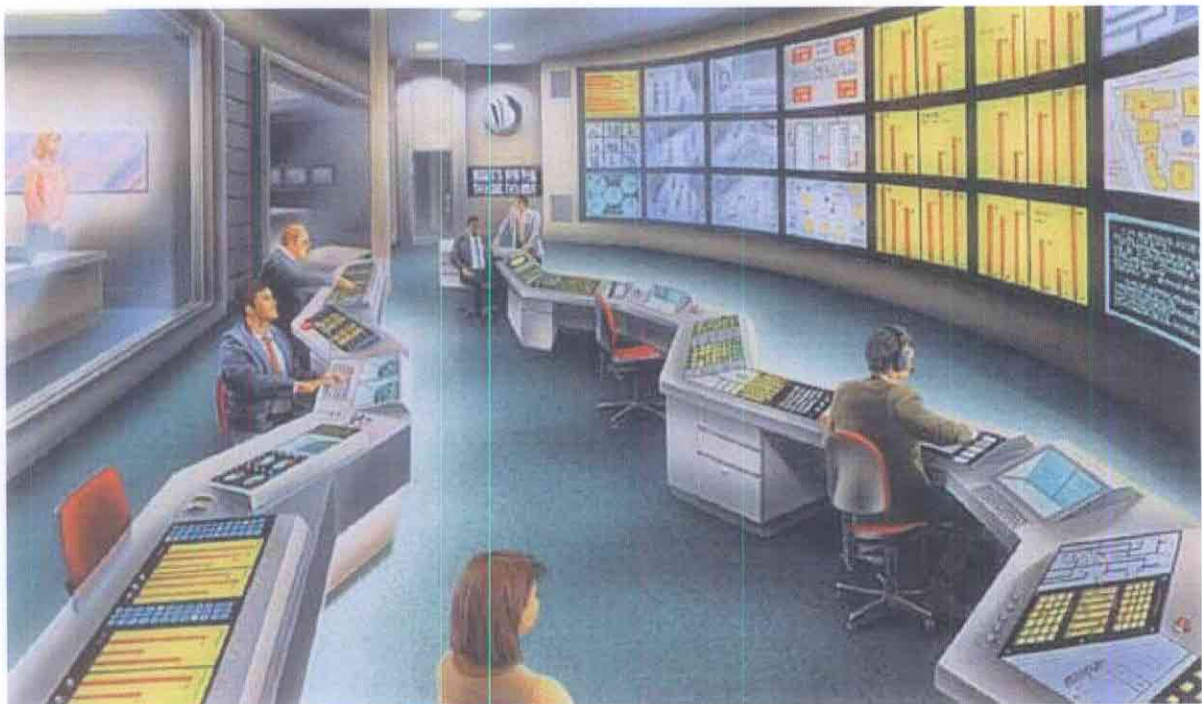


Illustration by Jeff Mangiat

The twin skyscrapers—the centerpiece of lower Manhattan—shut their doors for more than a month. The explosion literally ripped the guts out of an American civil-engineering landmark.

And yet only six weeks later, the towers, which house more than 100 acres of office

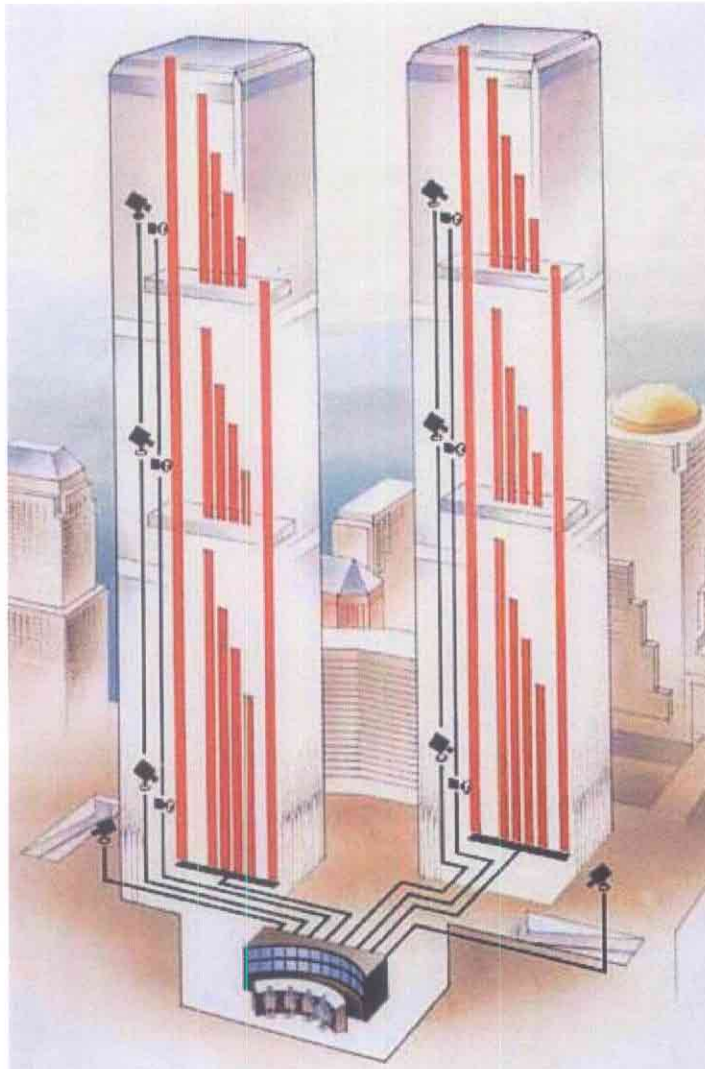
Maikish himself reached the ground floor within 30 seconds of the blast, thanks to a fire-department key that unlocked a paralyzed elevator. Not so lucky was Eugene Fasullo, chief engineer for the Port Authority of New York and New Jersey, which owns the tower complex. Trapped in an elevator 57 floors up,

space, were fully reoccupied. Bringing the buildings back to life has taken an unprecedented effort, one that combined on-the-spot engineering know-how with sheer elbow grease and the determination to shake off a low blow.

The disaster may also lead architects and engineers to rethink the way they secure the inner workings of skyscrapers—especially the electrical, plumbing and mechanical networks that keep these mammoth structures safely humming with activity. For it was the ravaging of those systems that brought pandemonium to the World Trade Center.

Fasullo and eight colleagues spent 3 hours chiseling through a sheetrock wall with a car key.

Raspy from smoke inhalation, Fasullo finally joined Maikish and a crew of Port Authority engineers at a makeshift command center in the ballroom of the Vista Hotel, a 22-story building sandwiched between the towers. By then, reports were already filtering up from the basement levels. Within an hour of the blast—even before the fire was out—engineers had ventured in to start assessing the damage.



The explosion damaged the original command center, located on level B1. A new highly automated operations-control center will feature 33 rear-projection screens that track elevators, show live video images from security cameras and update safety-system status. ILLUSTRATION BY ADOLPH E. BROTMAN

Pillars Of Strength

The wreckage was greater than anyone could have imagined, Maikish recalls. But the World Trade Center was in no danger of collapsing. "No other structure, no complex would have withstood that kind of blast," claims Maikish.

After all, the giant buildings are designed to resist a once-in-a-century wind blast of 150 mph. Each tower can sway up to 3 ft. in heavy winds. The instruments that record this swaying registered nothing from the explosion. The structures were also engineered to soak up the impact of a Boeing 707, the biggest plane in the skies when the towers went up in the late 1960s.

This strength arises from the towers' unique steel curtain walls, the exterior frames designed by architect Minoru Yamasaki. Twenty-one steel columns, spaced 10 ft. apart and braced with horizontal spandrels, make up each facade of the towers. These are the main load-bearing components of the structures. True, the explosion did not occur within the footprint of either building, but even the loss of 10 columns in a tower could not have triggered a collapse, says Fasullo.

Rubble Trouble

Some 2500 tons of rubble crashed to level 5, which was rapidly filling with water from ruptured pipes. Meanwhile, gigantic chunks of concrete hung menacingly around the 11,500-sq.-ft. blast hole, keeping engineers and crime-scene investigators at bay.

By early evening, Fasullo and his engineers had gauged the danger level. Some of the structural columns that held up the hotel had been severely weakened. In demolishing the floor slabs, the explosion had left the columns naked and unstable, with no lateral support for long vertical distances. The ruined slabs now lay three floors below in the 12-ft.-deep debris pile, which ironically lent some temporary lateral support for these columns.

But forensic investigators would still be at risk. And the agents were chafing to comb through the blast zone. "When they finally get in there, they're

Instead, the bomb delivered its blow to the 12-in.-thick reinforced-concrete floor slabs in the 6-level basement that lies below both the Vista Hotel and the plaza between the towers. Centered on level B2, the explosion shattered that level's floor slab and gouged holes through the two floors above. The blast also ripped downward to level B5, a cavernous, 3-story-high machinery area that houses the towers' refrigeration plant.

Normally, these floor slabs shore up a massive concrete foundation wall—the so-called bathtub wall that keeps earth and groundwater out of the basement. They also buttress nine structural columns that support the northeast corner of the Vista Hotel. Yet, although the slabs were blown to smithereens, they acted as blast deflectors, absorbing the explosion's energy and confining the structural damage.



[CLICK TO ENL](#)

A federal cr

going to look like a colony of ants going after sugar," remarked James Fox, assistant director-in-charge of New York's FBI office.

The engineers worked out an ingenious seat-of-the-pants solution. A work crew anchored a spider platform (so named because it hangs from a ceiling) to steel scaffolding erected on the concourse level. Motorized cables lowered the platform into the crater through a hole opened in the Vista Hotel ballroom floor, to provide a short, mobile catwalk for two welders.

At the same time, a contractor showed up with a supply of 4-in.-square steel tubes, each 40 ft. long, to provide horizontal and diagonal bracing for the columns. The welders would ultimately interconnect the weakened columns with 180 of these braces to restore lateral stability, all over a period of three weeks.

Once this process got under way, federal agents could safely pick through every fragment of rubble (although they had already disregarded engineers' warnings and taken chemical samples inside the crater). Among the debris, agents found the evidence—a piece of van chassis with a vehicle ID number—that led them to their first suspect: Mohammed Salameh.

About 240 workers, split into two 10-hour shifts, pulled rubble from the pit with the aid of a crane. The debris emerged through a 30-sq.-ft. opening dug into the Trade Center plaza. Fasullo said it was like playing pick-up-sticks: "If you pick up the wrong stick, the whole thing collapses."

Once the wreckage was removed, contractors could begin rebuilding the B1 and B2 floor slabs. Normally, they would have followed the standard pour-in-place procedure: They'd assemble a wooden framework below the floor level, top it with a form mold for the new floor, then lay out a network of steel reinforcement bars and pour in a foot-deep layer of concrete. This would have taken too long, though, because beneath B2 yawned the 3-level opening to B5, where work crews were repairing the refrigeration plant.

Instead, a construction team rebuilt the floor as if it were an above-ground story in a high-rise. They spanned the existing columns with steel I-beams, attached a grid of infill beams, placed a corrugated steel deck on top and poured 7 in. of concrete over that. On this sturdy platform, a second crew could mount shoring for a pour-in-place replacement for the B1 floor above.

Nervous Breakdown

While the basement's ruined skeleton preoccupied the engineers, rescue personnel had to contend with the Trade Center's shattered nervous system.

The blast had shorted out five of eight high-voltage feeder lines from Manhattan's electrical grid, and the fire department ordered the rest turned

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PHOTO BY



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off. Then a set of backup diesel generators overheated and shut down when the blast severed cooling-water lines. Communications, smoke-purge fans and lights went down within an hour of the blast.

One early priority was to restore power to certain elevators to aid the evacuation effort. Another was to return electricity to the subway tracks beneath the Trade Center.

The complex's electric power also feeds two telephone switches that serve lower Manhattan. Each switch has two hours of backup battery power. While one handles 70,000 international lines, the other is a major switch for NYNEX, the Northeast's regional telephone network.

"Once that switch goes down," notes Maikish, "major portions of New York would have lost telephone service." Maikish pressed hard to restore power to the switches, because telecommunications for the regional air traffic control system also run through the NYNEX switch. Before the disaster could spread beyond the Trade Center, however, the three intact electrical feeders came back on line.

Speed Cleaning

Despite the daunting damage, restoration of the Trade Center has moved faster than anyone predicted.

Air conditioning, its refrigeration plant crushed under the rubble, remains the only system not fully revived. Maikish expected three of the seven 7000-ton chillers to be operational by the start of summer. Outside the towers, rented units on trucks are lending additional cooling.

Meanwhile, armies of workers performed the emergency surgery needed to resuscitate the twin towers.

Electricians bridged thousands of feet of severed wiring in the fire-alarm system. Other technicians restored the damaged high-voltage feeders. Twenty more electricians, working around the clock for a week, cleaned and tested the towers' 3000 smoke detectors, a job that normally takes six months.

Once pumps had drawn nearly 2 million gallons of water from the basement, plumbers moved in on thousands of standpipes and fire pumps. They also had to check and recharge 1.4 million feet of sprinkler-system pipe before tenants could move back in. In addition, the valving in 4000 sinks and toilets was checked and reset—a precaution against flooding—before water pressure returned.

Workers repaired or replaced hundreds of stairway doors broken by firefighters or fleeing tenants. Within three days, glaziers had replaced hundreds of broken windows, including several 4-story glass windows in the lobby of the North Tower. It took two weeks to restore all vital services. Then Maikish sent in 2700 workers to clean the towers. Seven days were



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Ground zero
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PHOTO BY

needed to clean the South Tower, 10 days for the North Tower. Acres of stainless steel in the lobbies were polished clean of soot.

The Vista Hotel hasn't fared as well and won't re-open before August. The blast devastated the hotel's utilities, and contractors couldn't run new plumbing and electrical lines into the building until structural repair work at the blast site wound down.

Fail-Safe Future

What can be done to prevent this type of disaster from recurring? "You can't bomb-proof against a 1500-pound explosive," says Robert DiChiaro, Maikish's deputy. Nevertheless, the Port Authority is taking steps to reorganize safety systems.

For one thing, an additional feeder from the electrical grid—low enough in voltage not to threaten anyone knee-deep in flood water—will back up the smoke-purge systems. Battery-powered lights will illuminate the stairways. Workers will install new-generation smoke detectors that reveal their location when triggered.

In addition, a new radio-frequency phone system is in the works. The chaotic rescue effort demonstrated that walkie-talkies can't override the inevitable voice clutter that erupts during an emergency. By contrast, RF phones restrict themselves to one 2-way conversation per channel.

The Port Authority also plans to expedite the installation of a new state-of-the-art operations nerve center, with satellites in the lobby of each building. The \$18 million project will help coordinate procedures in the event of future disasters. In the meantime, Port Authority officials take pride in the speedy return to business-as-usual at the World Trade Center. But when Charles Maikish could get back to his office, he found the lease he was signing covered with soot. Blowing off the grime, he saw that he had only signed the first letter of his last name when he dropped his pen to respond to the emergency.

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