Nuclear Pulse (II): Ensuring Delivery of the Doomsday Signal

The President might not be able to issue the last call to arms due to the chaos-producing effects of electromagnetic pulse

Defense strategists today assume that a single Soviet warhead detonated 200 miles above Nebraska would knock out unprotected communications equipment all across the United States. The reason is electromagnetic pulse (EMP), a by-product of high-altitude nuclear explosions that blankets huge tracts of the earth with peak fields of 50,000 volts per meter.

The first installment of this three-part series described how EMP was discovered and why its potentially chaos-producing effects were overlooked for more than a decade. The second part examines the ongoing debate in the Pentagon over how to cope with the EMP threat. The third part will discuss questions EMP raises about waging a limited nuclear war.

The rule books of war say the President has 43 different ways of sending out what is known as an Emergency Action Message (EAM) to the strategic U.S. nuclear forces. A nonspecialist might think of this signal as the last call to arms. According to the Pentagon, the core of the EAM system is "especially designed to endure the effects of jamming, physical destruction, nuclear blackout, and electromagnetic pulse."

Hints from the Pentagon suggest that these claims are a bit hyperbolic. Consider the case of the Strategic Satellite System (SSS), a proposal for a doomsday network that would give the President an additional way to send an EAM signal. During congressional hearings in 1980, Air Force Secretary Hans Mark discussed the SSS with former Representative Robert N. Giaimo (D–Conn.), suggesting in a brief aside that 43 emergency channels were not enough.

Mark: "The difference between this communications system and the other 43 is that the SSS is more certain to survive a full-scale nuclear exchange."

Giaimo: "The others are not?"

Mark: "The others are less survivable, sir."

The SSS did not get off the drawing board, a victim of congressional and military indecision over how to cope with the problem. The search for solutions to the communications gap, made all the more urgent by the awakening to the threat of EMP, continues throughout the military. So does a certain schizophrenia. The Pentagon has quickly incorporated some EMP-resistant technologies and design strategies into its communication links, and has totally ignored others. Small telephone companies, for instance, are pioneering the use of EMP-resistant technologies such as fiber optics, but the Pentagon prefers to stick with its old standby, the Bell System, which is the sole U.S. common carrier with which it does business. The cumulative effect of this communications patchwork is that no one seems quite certain whether the whole military network would function in the midst of a nuclear exchange. In light of these problems, Secretary of Defense Caspar Weinberger in April called together a high-level, service-wide "strategic connectivity executive review board" to wrestle with the problem of designing a communications system better able to survive the effects of nuclear war.

Not considered a reliable part of the military network are the old-fashioned ground-based communication links. For one thing, the amount of EMP picked up and delivered to sensitive electronic components depends on the length of the collector. The short antenna of an FM radio picks up hardly anything. A global communications web of copper cables, microwave towers, switching centers, and command posts picks up quite a lot. Moreover, the sheer size of such a network makes it almost impossible to test it exhaustively for hardness to the effects of EMP, and the few tests carried out have not been encouraging.

An example is the Autovon network, a high-priority system built by Bell for the government. A widely read communications textbook (*1*) holds that Autovon is "nuclear bombproof." Disagreeing with this assessment is James W. Kerr, an EMP specialist with the Federal Emergency Management Agency. Kerr says that an Autovon switching center was exposed to simulated bursts of EMP in 1975, and that damage was extensive. "We know how to protect to a certain extent," he says, "but the EMP problem is not susceptible to cure."

A more reliable system is one based on satellites, and the Pentagon now in fact relies on satellites for more than 70 percent of its long-haul communications. Half this capacity is leased by the Pentagon from commercial vendors and half is provided by Pentagon-owned satellites such as those of the Defense Satellite Communications System. Applications for satellites are almost infinite. The Washington to Moscow hotline is transmitted by satellite, one Soviet, the other a commercial satellite belonging to Intelsat. The Air Force is thinking of installing satellite ground stations at the phased-array radars just going into operation along the Massachusetts and California coasts. Plans are under way to equip the launch control centers of the 1000 Minuteman missiles scattered across the American heartlands with satellite ground stations. At least 400 Navy ships today have satellite links. By 1988, the Navy expects to be using 1100 satellite terminals. Almost all B-52 strategic bombers are equipped with satellite terminals, and every airborne command post, such as the "looking glass" planes of the Strategic Air Command that constantly circle over the United States, can signal their commands by satellite.

The comparatively low cost of transmission is one reason the Pentagon is relying more and more on satellites. Another is survivability. X-rays from a nuclear blast in space can produce a high-voltage electric pulse in a satellite (called system-generated EMP). Unlike huge, ground-based networks, however, a satellite can be tested to ensure that EMP

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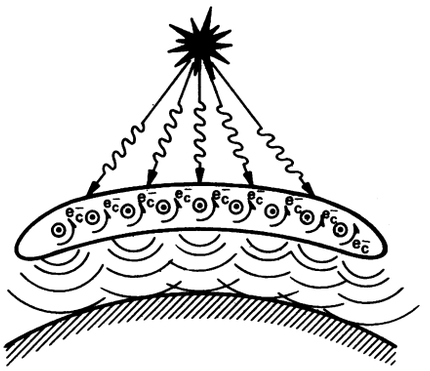
hardening and protective measures against far-flung particles from a nuclear blast have taken hold. Ground stations can also be hardened.

A factor against satellites is that they are vulnerable to Soviet satellite killers and the possibility of a direct nuclear hit. It was for these reasons that the Strategic Satellite System proposed by the Air Force was scrapped. On the recommendation of a report by the Defense Science Board, Congress decided that a "proliferated" system was more survivable than a few more "dedicated" emergency communication satellites such as the SSS, which could easily be attacked by the Soviets. Dozens of U.S. satellites whose primary mission lies elsewhere are thus being equipped to send war messages. The Navstar Global Positioning Satellites, for example, will carry a small additional payload known as a single channel transponder for EAM signals. Since this is "extra" equipment, squeezed into a very small space, it is not very rugged or powerful. Some officials within the Pentagon are thus still arguing the case for a new series of dedicated satellites in addition to a proliferated network.



All nuclear bursts produce some EMP, but ones in space produce a very high-voltage wave that covers huge stretches of the earth. This happens because earth-bound gamma rays hit air in the upper atmosphere and knock out Compton electrons, which are deflected by the earth's magnetic field and forced to undergo a turning motion about the field lines.

On the ground, meanwhile, the Pentagon is pursuing fiber optics, which are widely used because they pack more communications channels into a far smaller space than ordinary electric wires. They also do not pick up EMP, and therefore do not transmit these high voltage pulses to fragile semiconductors such as integrated circuits. The Navy is using fibers to connect satellite ground stations with data processing centers for the Defense Satellite Communications System. The MX missile, if deployed on land, will use some 10,000 kilometers of fiber cable. Plans for the revival of the B-1 bomber call for extensive use of fiber to reduce EMP vulnerability.

Despite this growing reliance on fibers, the Pentagon has totally passed up one way of increasing their use in ground-based communication networks. For years, independent telephone companies such as General Telephone and Electronics have spent more on fiber optics than the Bell System, even though Bell accounts for some 80 percent of the new investment in telephone equipment in the United States.

Also in deference to the Bell System, the Pentagon has turned its back on an asset unique to the United States: the advent of competition in long-distance

Soviet poster signals dangers of EMP

Some Pentagon officials claim that the Soviets realized the significance of EMP much earlier than the United States, and have acted accordingly. This undated Soviet poster, allegedly off a factory wall, discusses the effects of EMP from a low-level burst. An exoatmospheric burst would produce serious effects over a much wider area. It reads in part as follows: "Electromagnetic fields arise from nuclear explosions which produce impulsive electrical currents and stress in aerial and ground conductors and cables, and in radio station antennas. Radio waves are also produced which propagate to large distances. . . . Effects for explosions of suitable overstress. . . . Burnout of the elements of electrical and radio apparatus or massive damage of protection devices. . . . Destruction of insulation on electrical and radio-technical installations. . . . Confusion of military staff."

communications (*Science*, 15 August 1980, p. 787). Unknown 5 years ago, specialized common carriers such as MCI Communication Corp. and Satellite Business Systems now claim an estimated 3 percent of U.S. long-distance telephone traffic. During the Carter Administration, an attempt was made to hook these companies into the U.S. defense network, on the assumption that redundant commercial communication links might better survive a nuclear showdown. In 1979, Carter issued Presidential Directive 53, an unclassified order encouraging "connectivity" so that "forces can support flexible execution of retaliatory strikes during and after an enemy nuclear attack." To this end, the order called for interconnection "to the maximum extent feasible" of the military and commercial system, including specialized common carriers, domestic satellite carriers, and the private communication systems of companies that own pipelines, railroads, and airlines. Little, however, was done to achieve these goals. Says Orville Wright, president of MCI: "I've been to the Defense Communications Agency a dozen times, and it always comes down to the same thing. They have some sort of unholy reliance on the Bell System."

This "unholy reliance" was recently made manifest by Weinberger, who asked the Justice Department to drop its 7-year-old antitrust suit that seeks to break up the Bell System. "I have written to the Attorney General and urged very strongly that the suit be dismissed," Weinberger recently told a congressional hearing. "It seems to me essential that we keep together this one communications network we now have, and have to rely on."

This avowed reliance is unusual from the standpoint of network survivability, for it is at odds not only with the Carter Presidential Directive on network redundancy but with the Pentagon's own longstanding policy of using satellites wherever possible. The Bell System has no satellites.

The situation is ironic, for the birth of the first communications satellite, Telstar, occurred at Bell Labs, and nowhere else has the potential for satellite communications been more clearly perceived. Political impediments, however, have arisen at every turn. First, in 1962, Congress created Comsat, which had a legislated monopoly over U.S.-based international satellite communications. Then, in 1971, the Federal Communications Commission (FCC) formulated its "open skies" policy, which signaled the start of the race to send up satellites for communications within the United States. A Bell Labs study at this time showed that a few powerful satellites of advanced design could handle far more traffic than the entire Bell System long-distance network, at a fraction of the cost. Bell applied for a license. The FCC denied the request, fearing that Bell would use its monopoly revenues to quash the competition. A number of corporations started to send up satellites, and have done so ever since. Bell, in the meantime, continued to spend many billions of dollars each year on expanding its ground network.

Denied the chance to launch its own satellites, and thus to cut costs and diminish the dangers of an EMP-produced blackout, the Bell System has nonetheless made the best of a bad situation. "We can be reasonably confident in the EMP hardness of the present Bell System," according to a 151-page book put out by Bell Labs that describes methods of hardening (*2*). It also notes, however, that "new systems make increasing use of integrated electronics and digital circuits that are more susceptible to EMP than discrete solid state devices and analog circuits."

Though expensive, trying to harden Bell System facilities against the chaotic effects of EMP is one potential strategy. Among other things, this can entail wrapping switching centers, repeater stations, and command posts with steel shielding. In the past, the Bell System did not charge the Pentagon for this service. The extra billions in design and construction costs were furtively passed on to consumers in their telephone bills, never showing up in the defense budget. Today, the Defense Department, if it wants to continue trying to shield the network in this fashion, is facing the prospect of having to pay for continued hardening. As a study (*3*) recently commissioned by Bell System Long Lines

Marriage of Ma Bell and Military

Part of the Pentagon's ritual reliance on the Bell System stems from habit. The bond between the two was forged in a serious way during World War II. Bell Laboratories performed 2000 projects for the military. Western Electric, the Bell System's manufacturing arm, helped produce radar and gun direction systems, communications equipment, sonar, proximity fuses, magnetic mines, and acoustic torpedoes.

Later, the Bell System built the first switched military telephone network, Autovon. Today it is the world's largest private network. The Bell System installed the communications equipment in the Combat Operations Center of the North American Defense Command, deep within a hollowed-out mountain in Colorado. For decades, Bell System engineers hardened cables and placed switching centers outside metropolitan areas, on the assumption that they would be the first to go in a nuclear attack. Bell was prime contractor on the Safeguard antiballistic missile system (see part I), and its predecessor, the Nike system. Bell managed the Distant Early Warning line of radar stations across the Arctic. Today, it runs Sandia Laboratories, which performs research and development for advanced nuclear weapons.

Pentagon dependence on the Bell System has been so great in the past that the military has gone out of its way to help Bell in courtroom battles (*4*). Consider a federal antitrust suit brought against Bell by the Justice Department in 1949. The key request was that Western Electric be divorced from the Bell System and split into three competing manufacturing units.

In 1952, the Bell System asked for a postponement of the suit for the duration of the Korean War, the Secretary of Defense echoing the request. On 23 June 1953, the Korean armistice was signed. Little more than a week later, Bell officials sent to the Pentagon a detailed memorandum on why the case should be dropped altogether. One week after that, Secretary of Defense Charles E. Wilson sent a three-page letter to the Attorney General saying that lack of an integrated Bell System would pose a threat to national security. Despite the appearance of impartiality, the letter, except for two short passages, was identical to the memo drafted by Bell officials. The pressure on Justice continued, and in January 1956, the suit ended—not in divestiture but in a mild consent decree that did not substantially limit the activities of the Bell System.—WILLIAM J. BROAD

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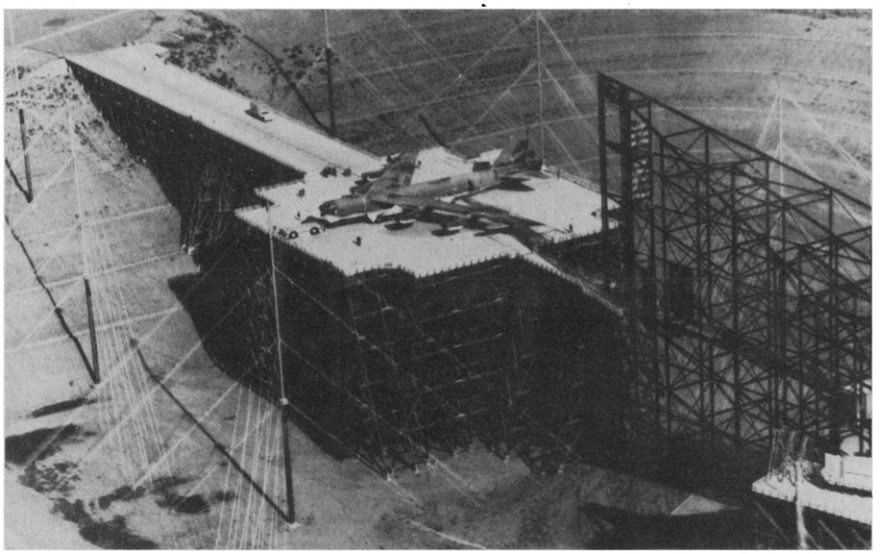


Air Force Weapons Testing Laboratory

EMP simulator tests hardness of B-52

Located at the Air Force Weapons Laboratory at Kirtland A.F.B. in New Mexico, the Trestle EMP simulator can discharge million-volt pulses into transmission lines surrounding an aircraft. The all-wood structure holding the B-52 is 12 stories high.

put it: "Historically, the costs of special measures requested by the government for national security purposes have been included in the rate base, on the theory that they benefit all users, public and private. With increasing competition, and especially if divestiture is forced, this method becomes impractical, since in each specific case there is a firm that will not want to incur the competitive disadvantage of requesting such additions to its rates."

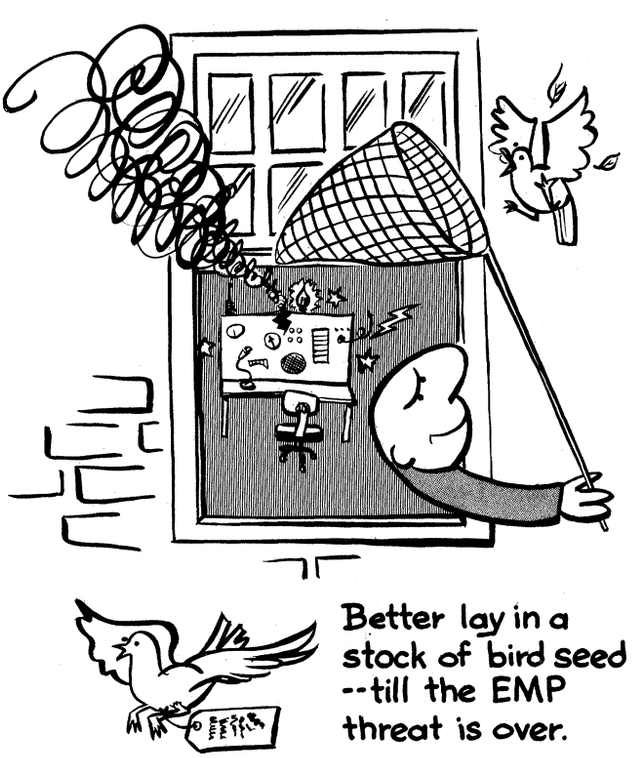
The question is whether a "hardened" system would be reliable. When pressed, even Bell officials admit that testing a ground network for hardness is difficult. "To the extent that a satellite has fewer parts, the job may be easier," says Sol J. Buchsbaum, former chairman of the Defense Science Board and current vice president for military systems at Bell Laboratories.

What is the Pentagon to do? The hardness of the ground network is in doubt, and its favorite telephone company has lagged behind fast-moving competitors who have introduced technology better able to withstand the threat of EMP. One option is for the Pentagon to wait, on the theory that time cures most anything. With satellites, for instance, the FCC recently decided that competitors can now withstand the Bell System threat. By 1983, Bell will launch Telstar III, its first satellite in more than two decades. Bell is also planning to install a 496-mile fiber optic line between Washington and Boston—the first of many such conduits. Unfortunately, this first link will not be completed until 1984.

Another option for the Pentagon is to admit that the marriage to Ma Bell may have outlived its usefulness, and acknowledge that free market communications may serve the military better than memories of the Bell monopoly. After all, Bell Labs may have invented the laser (a key component in fiber optic systems), but it has been other telephone companies, not the Bell System, that have put it to use by pioneering fiber optics in the marketplace.

Though a divorce from Ma Bell might help, it would not guarantee that the Pentagon's network would survive a nuclear attack. Satellites, for instance, are easier to test than a sprawling, ground-based network, but that job has only just begun, the first full test for nuclear hardness occurring in 1980 at the underground test site in Nevada. Moreover, questions remain about a myriad of critical links. One is whether satellite signals would be able to penetrate the ionospheric disruptions caused by high-altitude nuclear blasts. Another unknown is ground links. According to Harry A. Griffith, head of the Defense Nuclear Agency, full testing of ground stations to the "communications link disturbances caused by high-altitude nuclear weapons" will not even begin until 1982. Hardening may take longer. Even the Presidential airborne command posts, four especially designed Boeing 747's, are potential weak links. Only one plane is EMP hardened. The other three, on call 15 days out of every month, have as many as 11,500 essential circuits that would fail if the planes were hit by an electric pulse from a nuclear burst thousands of miles away. The hull penetrations (windows, doors, cable connections) that would admit EMP will not be sealed until sometime in 1983.

The troubling question is what the President should do in the meantime. The official answer at the Pentagon is "nothing," since all the rule books say there are dozens of different channels by



This cartoon, drawn by Don Clark at the U.S. Naval Civil Engineering Laboratory, was included in a 1973 Department of Defense booklet for civil defense planners on the EMP threat. It does not necessarily represent the views of Pentagon planners who design emergency communication networks for Presidential war directives.

which the President can contact the U.S. nuclear forces. These include a plethora of cables, satellites, microwave relays, and special radio transmitters. However, reams of congressional testimony concerning the state of U.S. military communications and the EMP threat tell a different story. Consider the statements made in 1980 by Gerald P. Dinneen, at the time the Pentagon's ranking specialist on communication issues. The United States, Dinneen said, should never do anything that would "reduce the deterrent," that is, never do anything that might tell the Soviets the United States is anything less than ready to massively retaliate in the event of a Soviet first strike. "That is why I think discussions of these things . . . should be held in closed session," he said. "Some of the comments about the weaknesses of our command and control system must be kept at a very high level of classification." —WILLIAM J. BROAD

References and Notes

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FDA Sees No Radiation Risk in VDT Screens

Eye strain may be a problem, but federal officials are unpersuaded by x-ray and microwave complaints

Staring at classified ads on a flickering television screen for 7 hours a day, 5 days a week may very well produce headaches and other pains, but it does not produce deformed children—the scare raised last year by several employees of the Toronto *Star* in Canada. There is no reason, according to testimony given in Congress in May, to think that the video display terminals (VDT's) used by millions of computer operators and typesetters around the world emit harmful radiation. That is the essence of the testimony given by engineers and radiological specialists at hearings on 12 May chaired by Representative Albert Gore, Jr. (D–Tenn.), before the investigations subcommittee of the House Committee on Science and Technology.

"One of the beautiful things about radiation," according to John Villforth, director of the Bureau of Radiological Health at the Food and Drug Administration (FDA), is that "anyone who's paranoid can blame their problems on it." The FDA, which is one of several federal agencies investigating video hazards, essentially sees the problem as a case of misplaced blame. People with legitimate but mundane complaints about VDT's have latched on to the radiation theme, in the FDA's view, because radiation threats are general enough to subsume all dissatisfactions under one heading. The folly of this attitude, as the FDA sees it, is that there is no physical evidence to support it. Some FDA officials worry that, in the search for more and more definitive information on the VDT-radiation theme, money will be frittered away on dead-end research projects, while the more important hazards of medical radiation will be left not fully explored. At the same time, the real problems associated with VDT's—eye strain, headaches, boredom—may not get the attention they deserve.

The first VDT-radiation scare arose when VDT's were being installed in newsrooms in the middle 1970's, according to Charles Perlik, president of the Newspaper Guild. Speaking at the 12 May hearings, Perlik said, "There was concern at the very start among our members that these machines might be emitting radiation. . . . Their concern was about the possibility of x-rays, since the introduction of VDT's came only a short time after x-ray emissions had been discovered in the VDT's lineal ancestors, color television sets." But Perlik said the potential x-ray hazard was studied by the Occupational Safety and Health Administration (OSHA), and dismissed as minuscule. The Guild did not want to take any chances, however. As part of its collective bargaining program, it demanded routine testing of VDT's in certain newsrooms to reassure Guild members that they were not being riddled with x-rays.

Soon the focus of concern shifted from x-rays (ionizing radiation) to low-frequency radio wave emissions (nonionizing radiation) coming from VDT transformers. The "cause célèbre" of this phase of the controversy, as Perlik called it, appeared in 1976. Two young *New York Times* employees, Samuel Weiss and John Woodford, discovered at the same time that they had developed cataracts. They were 29 and 35 years old, ages at which cataracts rarely appear. Neither was judged to be particularly susceptible by virtue of having diabetes or showing a family history of cataracts. Was it possible that the VDT's were causing the trouble? High doses of heat-inducing radio waves, more than 10,000 times the frequency of VDT emissions, have produced cataracts in rabbits' eyes. Perlik said the *Times* case "awoke us to the possibility that our members might be exposed to the hazards of nonionizing radiation." A new study was undertaken, this one directed by the National Institute for Occupational Safety and Health (NIOSH). Like earlier investigators, NIOSH found no threat from VDT radiation: the levels were too low and of too low a frequency.

The two newspaper employees, however, consulted an ophthalmologist named Milton Zaret, who diagnosed their ailments as "radiant energy cataracts" caused by exposure to microwave emissions from the VDT's. A physician for NIOSH, Jacqueline Messite, looked at the same medical data and found that the cataracts were "compatible with those reported from radiant energy, but . . . also compatible with those seen congenitally or those associated with other etiologies." Since NIOSH investigators had found no evidence that microwave radiation was reaching the VDT operators, Messite concluded that "the etiology of the cataracts remains undetermined." More bluntly, NIOSH removed the substantiation for Zaret's diagnosis.

Zaret objected vociferously on half a dozen technical grounds, compelling the Guild and the *Times* to enter into arbitration on the technical dispute. They agreed on an arbitrator, Maurice

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