

ENGINEERING PLANNING
LONG LINES PLANS FOR SURVIVABLE
COMMUNICATIONS

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1. General

1.01 Regular Bell System construction practices provide for protection to telephone plant against natural and the usual man-made hazards. The threat of a nuclear attack with possible widespread destruction of plant presents different problems in providing maximum survivability of communications services. This section is reissued to

describe the additional measures to be considered by Long Lines Engineers in planning new routes and buildings to provide survivable communications service in the event of a nuclear attack.

1.02 There is no practical way of protecting communications if they are directly targeted by nuclear weapons. A method for achieving survivable communications is to provide diverse facilities and to protect some of these against the effects of collateral damage likely to be caused by nuclear weapons directed at nearby targets. The extent of collateral damage will vary depending on the proximity of a target, accuracy of the weapons, the size (yield) of the nuclear warhead and the type of attack (air burst or ground burst). Probable yield depends on the nature of the targets and on the selected probability of kill for each of these. Past and future trends indicate the most likely range of warhead yields for the majority of targets is from 0.5 to 20 megatons (MT). The protection measures recommended in this practice are based on a 10 MT air burst as most representative of the threats which require protective measures. This is also supported by Multiple Independent Reentry Vehicle (MIRV) technology which tends to minimize the size of warheads.

2. Purpose

2.01 As long as the threat of nuclear attack exists, the Long Lines Department will apply protection measures to improve the reliability and survivability of Bell System services. The Long Lines intertoll network growth plan is to connect major Metropolitan Areas by a facility grid arrangement known as the Corridor Plan. Since the major cities comprising the Metropolitan Areas of this plan are potential target candidates, a method of bypassing these areas is required to retain network connectivity during a nuclear attack. Junction offices connect the backbone facility routes between the metropolitan areas and have

been designed to survive collateral damage through such measures as avoidance and/or hardening. Entrance facilities from the junction offices and the terminal offices are considered to be within potential target areas. Neither the terminal offices or the entrance facilities need be designed to survive nuclear overpressures. Therefore, even if a major city is destroyed, communications to other points in the intertoll network can be routed around the damaged area via the junction offices which should survive the collateral damage effects of the attack.

2.02 All new construction will not need to be planned and built in a survivable manner. In fact, the existing network provides nearly all the survivability which is thought necessary for the near future. The need for additional survivability or hardened facility systems will be reviewed periodically by the Engineering Manager, Facility Planning, to determine if and where it is required.

2.03 The purpose of this Section is to outline protection measures to be used where survivability is required.

3. Protection Measures

A. General

3.01 To provide for growth in Long Lines services, it is often necessary to build new radio relay, coaxial cable, waveguide, satellite or other systems. To provide these services it is often necessary to build new buildings and to install new terminating and switching equipment. The opportunity to provide protection and survivability (if required) at a minimum cost and with maximum effect is at the time of construction of this new plant. It is not feasible to harden satellite facilities so this section does not include it as a possibility. Waveguide, where employed, is likely to be in established corridors where survivable facilities already exist. It is not planned to harden waveguide systems at this time.

3.02 The terms "manned" and "unmanned" are used along with "attended" or "unattended" throughout this Section. "Manned" or "attended" refers to those locations where the presence of people is required for the normal maintenance and operation of equipment located therein. "Unmanned" or "unattended" is used

to describe a location where a building and its equipment are designed to operate without the presence of people.

3.03 The protection measures required to achieve survivable communications are grouped into the following seven categories.

- a. Diversity
- b. Separation
- c. Avoidance
- d. Hardening
- e. Protection of People
- f. Rapid Restoration of Service
- g. Emergency Control Centers

B. Diversity

3.04 Over the years the Bell System has installed numerous facilities in nearly all cross sections interconnecting the toll network. Even though many of these routes may not have been constructed to meet survivability criteria their diversity increases the probability of network survival to nuclear attack. This diversity of routes also makes it possible to minimize the number of hardened facilities we may need to construct in the future.

3.05 It is necessary to provide diversity of the junction offices where line facilities interconnect so that the loss of a single office will not cause complete loss of service to an area. The Metropolitan Junction Plan provides this diversity, however, appropriate separation between offices must be provided along with avoidance or hardening measures to protect these offices against the effects of collateral damage. Each major city needs a tailored Metropolitan Junction Plan. These plans must be coordinated so that facilities separated under one plan are not brought together under another city's plan. More specific planning information on Metropolitan Junction planning can be found in Section 800-101-100.

C. Separation

3.06 In planning new survivable routes, consideration should be given to adequate separation from other diverse routes. Separation reduces the possibility of both routes being destroyed by a single detonation. Table A lists the recommended separation between various types of structures on the different routes and is prepared for the guidance of planning engineers. It is recognized that, due to congestion of facilities in certain areas, strict adherence to these criteria may be difficult or even impossible. Compliance is recommended where feasible. Separation between parallel corridors interconnecting two metropolitan areas is most important. Once these corridors are established it will not be necessary to use the separation criteria in these tables on additional facilities that might be added to the same basic corridors and existing rights-of-way.

Note: Where it is necessary to have cables cross one another it is recommended that at least one of the cables be placed in steel pipe for improved survivability and protection against day-to-day troubles. For additional details, refer to Section 915-900-911 LL.

D. Avoidance

3.07 Cable and Radio systems which form the initial backbone routes of the Corridor Plan should be constructed to survive potential collateral damage from a nuclear attack. Table B lists target area avoidance data based on the blast resistance of various telephone structures. In planning interjunction office routes for the Corridor Plan, the Area Engineer should be guided by his first hand knowledge of the terrain involved and the proximity of the route and buildings to potential target areas such as large metropolitan cities or government installations. In addition to this, tentative site locations and routes should be referred to the Engineering Manager, Facility Planning for vulnerability evaluation. This is done by submitting the latitude and longitude coordinates for all proposed radio relay sites and cable power feed and main stations up to and including the junction offices.

Side legs from the junction offices to terminal offices or satellite earth stations are considered vulnerable and need not be

submitted for evaluation. For a cable route, the proposed routing should be indicated on a World Aeronautical Chart (WAC) Scale 1:1,000,000. The routes and sites will be analyzed, and if a conflict exists, recommendations for relocation will be made to avoid the necessity of constructing buildings to a hardness greater than 2 PSI unless additional cost makes it a more practical alternative. The current policy places a minimum construction hardness of 2 PSI on coaxial cable buildings. However, where avoidance routing unduly increases cost it may be more economical to harden a building to 10 or 50 PSI to obtain the desired degree of survivability. Radio routes can be built at 1/2 or 2 PSI depending on overpressure requirement and radiation protection required (See Section F). They should be checked for these ratings so that where possible the economies of 1/2 PSI construction may be realized.

E. Hardening

Cable Systems

3.08 Modern buried coaxial cable will inherently survive overpressures of 150 PSI because of its physical design. Current standard repeater manholes will survive 50 PSI overpressures. Figure 1 shows a cutaway view of the standard 38Y manhole to be used on L4 and L5 coaxial cable routes. Whenever coaxial cable has been the economic choice for route planning, it inherently meets all the hardening criteria necessary on the backbone routes of the Corridor Plan. The power feed and terminal buildings on these routes may or may not require special hardening protection depending on the expected nuclear overpressures in the locations where they are planned. Avoidance minimizes this need. For this reason it is important that proposed sites be evaluated for these expected overpressures prior to acceptance of a route layout. Where overpressures are expected to exceed 2 PSI some movement of the proposed site may be desirable and possible to bring it into 2 PSI territory where extra hardening measures won't be required. The current standard design for L5 power feed building has been established to meet 2 PSI nuclear overpressures. This design also provides protection against EMP vulnerability (discussed later). Although it is highly desirable to avoid building to greater than 2 PSI hardness, there may be

TABLE A
SURVIVABILITY CONSIDERATIONS FOR LONG LINES ROUTES

ROUTE SEPARATION CRITERIA

(10 MT WEAPON - AIR BURST)

ADJACENT TELEPHONE STRUCTURES	SEPARATION IN STATUTE MILES
2 PSI - 2 PSI	36
2 PSI - 10 PSI	24
2 PSI - 50 PSI	21
10 PSI - 10 PSI	12
10 PSI - 50 PSI	8
50 PSI - 50 PSI	6
50 PSI - 100 PSI	5
100 PSI - 100 PSI	4

Note: Separations for 0.5 PSI have been omitted since these locations are generally in areas not expected to be targets and the separation distances are prohibitive.

TABLE B
SURVIVABILITY CONSIDERATIONS FOR LONG LINES ROUTES

TARGET AREA AVOIDANCE CRITERIA

(10 MT WEAPON - AIR BURST)

TELEPHONE STRUCTURE	STATUTE MILES FROM POTENTIAL TARGET
0.5 PSI	40
2 PSI	18
10 PSI	6
50 PSI	3
100 PSI	2

instances where movement is impossible and 10 PSI or 50 PSI hardening may be required. These situations should be investigated on an individual case basis by the Area and Headquarters Engineering (Fundamental Planning and Transmission Planning) before a final resolution is made.

Radio Systems

3.09 Radio relay systems and buildings which make up backbone routes in the Corridor Plan may be of 1/2 or 2 PSI construction depending on the expected nuclear environment and whether they will be attended or unattended. Where main junction buildings on radio relay routes are attended, a building having sufficient mass to meet the 100 PF radiation protection is required. Unattended radio relay buildings are to be constructed to 1/2 or 2 PSI hardness depending on the expected nuclear environment. Hardening of radio relay systems to withstand overpressures greater than 2 PSI is costly and is not recommended except for those few cases involving special customer needs. Radio equipment should be mounted in the normal manner (not shock mounted).

F. Protection of People

3.10 Following a nuclear attack, it is expected that the major part of the contiguous 48 states will be blanketed with radioactive fallout. Therefore, it will be necessary to reduce exposure of personnel to this danger while they are operating communications equipment essential for the transmission of through services. The following buildings are considered necessary for network connectivity and are to have fallout protection in the essential work areas as well as provisions for emergency food and safe water supplies for operating personnel.

- All manned buildings making up the backbone routes of the Corridor Plan.
- Other manned buildings including switching offices which principally handle through services.

The L5 Power Feed buildings and most other power feed buildings are designed to be unmanned and need not have radiation protection.

G. Rapid Restoration of Service

3.11 In the event of major damage to plant, it is necessary to provide for rapid restoration of service. Restoration consists of rerouting service on other facilities, temporary physical replacement of damaged plant, and permanent repairs. Restoration is performed on a single circuit basis for priority circuits and at mastergroup (600 circuits) or multi-mastergroup levels for other services.

3.12 A limited amount of protection facilities are provided in our plant for maintenance and reliability reasons (e.g., repeater failures, deep fades due to climatic conditions, or other equipment troubles affecting a single channel). For coaxial cable routes, two of the coaxial tubes within the cable are designated for protection; one tube in each direction. A similar system is used on microwave radio systems. If a working coaxial tube or radio channel fails, the service is automatically switched onto the protection channel without interruption. In the event that an entire route fails due to the severance of a coaxial cable or destruction of a radio tower, automatic protection switching does not provide for restoration of service.

3.13 Broadband (mastergroup and multi-mastergroup) restoration is the responsibility of Facility Management and is accomplished, on a limited basis, by using the protection facilities of other routes. To accomplish broadband restoration efficiently the Bell System has established a Facility Management hierarchy. The facility network is divided into eight regions, each under the control of a Regional Operations Control Center (ROCC) subtending to the Operations Control Center (OCC). Of the eight ROCC's, six are operated by Long Lines, one by Pacific Telephone and Telegraph Company, and one by the Bell Canada. The OCC is operated by Long Lines and collocated with the National Message Network Management Center. The OCC maintains communications with the ROCC's, Bell Canada, Overseas Operations, Government Communications Centers, and the Message Network Management Centers. The OCC/ROCC hierarchy is to maintain a constant surveillance of the facility network, control all restoration activity in its territory, coordinate restoration activity with other

ROCC's and insure optimum use of the protection facility network during abnormal conditions. Additional information concerning the functions and responsibilities of Facility Management (OCC and ROCC's) is outlined in Section 002-503-900 LL.

3.14 In the past, the patching and switching operations needed to restore disrupted services were performed manually and required considerable time and manpower. To increase efficiency, the installation of restoration patch bays, self-healing order wires, 560 kHz continuity tone and detector circuits, and remotely controlled matrix switching equipment at selected remote offices has been accomplished as follows:

- a. Self-healing order wires and 560 kHz continuity tone and detector circuits have been authorized for all regions.
- b. Restoration patch bays requiring manual patches to accomplish a reroute are installed in the Northeastern, N.Y. City, Eastern, Central, Southern and Midwestern Areas.
- c. Push button restoration control bays and switching matrices have been provided in the Midwestern and Western Areas. Rerouting is accomplished locally or remotely by means of the remote command and alarm systems.

3.15 As higher capacity coaxial cables are placed into service, their restoration capability becomes more limited. Studies of the possible effects of failures to high capacity systems such as L4 and L5 indicate that in most cross sections a limited number of mastergroups could be rerouted if a total route failure is experienced. The effects of a total route failure on the message network can be appreciably reduced by adequate diversification of circuits. The guidelines for diversifying message circuit groups can be found in Engineering Administrative Practices.

3.16 Diversification and limited restoration does not provide all the relief required in a total line failure such as an L4 or L5 coaxial system. Some priority private line services without diversity and other critical

message trunks* will be of particular importance to the continuity of traffic flow and should be selectively restored. A Key Line concept has been planned for high capacity transmission facilities to consolidate the critical trunks onto a maximum of six contiguous mastergroups (Key Line). In the event of catastrophic failure of the route, the mastergroups assigned to the Key Line would have first call on any available paralleling facilities. Key Line is scheduled for implementation starting with the 1978 construction program.

3.17 In addition to rerouting, plans have been made to physically restore damaged plant. Emergency restoration equipment in mobile modular form and arrangements for its use have been provided for most facilities. Equipment currently available or planned is as follows:

- a. Emergency TD-2 Microwave Restoration
Equipment: This equipment consists of all the necessary components required to restore a TD-2 auxiliary repeater station on a through-channel basis. Since units are in strategically located storage centers, it is not necessary to travel more than 350 miles to reach any particular site. A complete unit consists of two radio trailers (each capable of restoring six channels in one direction, or three channels in two directions), two power trailers, one antenna-tower trailer, and one tower trailer. Currently, Long Lines has 13 completed units strategically located, and Pacific Telephone and Telegraph Company has a number of similar mobile radio packages in its territory. Additional information concerning this equipment is found in Section 002-503-986 LL.

- b. Emergency TH Microwave Restoration
Equipment: This equipment consists of radio vans designed to work in conjunction with existing TD-2 restoration trailers, towers, and antennas. Included in each van are all the necessary components required to restore a TH auxiliary repeater station on a through channel basis. Long Lines has

* Studies indicate that these should be High Usage circuit groups rather than Fulls or Finals.

four such units strategically located within the United States for rapid use when required. Additional information concerning this equipment can be found in Section 002-503-987 LL.

c. Coaxial Systems Restoration Equipment:

This equipment consists of specially designed coaxial cable patch cords and connectors to restore a damaged coaxial cable and all the necessary components required to restore a line repeater station. This equipment is strategically located along major coaxial routes. Additional information concerning this equipment can be found in Section 632-800-321.

H. Emergency Control Centers

3.18 In the event that regular administrative offices are destroyed, an emergency control plan has been provided. The emergency plan consists of a National Emergency Control Center located at Netcong, New Jersey and two alternate control centers located at Rockdale, Georgia and Fairview, Kansas. In addition to the national centers we have Area, Division and District Emergency Relocation Centers (ERC's) which are usually located at nearby survivable buildings. Telephone and telegraph communications are provided between the various ERC's and the National Emergency Control Centers. The National Emergency Control Centers have direct communications to several Federal Agencies located at diverse sites throughout the United States.

3.19 A detailed description of the emergency control plan is contained in Section 002-501-101 LL. In brief, the trained people at the centers will perform the following functions during an emergency.

- a. Receive reports and summarize the nature and extent of plant damage and other destruction.
- b. Keep higher management informed.
- c. Coordinate restoration activities.
- d. Report plant conditions to government agencies (such as FCC and GSA) and essential customers.

- e. Receive service requests from essential military and government agencies and arrange for the execution of such requests.

Practice sessions under simulated emergency conditions are conducted in order to examine the operations and to insure that adequately trained personnel are readily available.

4. Survivable Buildings

A. General

4.01 The threat of nuclear attack places great importance on a reliable and survivable communications network for both government and civilian requirements. As long as this threat exists some special measures will be necessary to harden essential buildings where avoidance does not adequately protect them against the effects of collateral damage. Most of these measures will be confined to the buildings located on the major backbone facility routes of the Corridor Plan.

B. Junction Buildings

4.02 Junction buildings on either coaxial or radio routes will generally be manned and must be built to provide a minimum degree of protection for personnel essential to the work operations of these offices and protection of the equipment. These buildings must satisfy the requirements of the Metropolitan Junction Plan and also the separation and avoidance criteria recommended in Tables A and B while simultaneously minimizing the need for hardening to keep construction costs low.

4.03 Main junction buildings on radio relay routes need not be built stronger than the maximum practical hardness of the antenna systems associated with the sites. The standard radio relay antenna will withstand up to 2 PSI overpressures. Therefore, sufficient avoidance of potential target areas is of prime importance if radio routes are to meet overall survivability requirements and keep them from exceeding 2 PSI construction. Figure 2 shows a typical above ground radio junction building.

4.04 Main junction buildings on coaxial cable routes are to be constructed of sufficient hardness to meet expected overpressures for the site selected. While it is desirable to minimize hardness and construction cost with proper avoidance it may not always be possible to do so because of extra cost or transmission and routing constraints. Unlike radio systems, coaxial cable has an inherent hardness of 150 PSI and does not restrict the maximum hardness of the building design. Figure 3 shows a cutaway view of a hardened underground main junction or power feed station. Separations criteria and general economics, however, establish a practical maximum at 50 PSI except in unusual circumstances where greater hardness is required for special projects at extra cost to the customer. Junction buildings serve metropolitan areas, and will have "soft" terminating legs to switching offices in these areas. The equipment associated only with these sidelegs is considered expendable under nuclear attack conditions and need not be confined to hardened underground space. Therefore, where underground space is at a premium the following measures are recommended:

- (a) Build the initial underground structure to accommodate all through - route and cable sideleg equipment, including mastergroups, supergroups, and connectors.
- (b) Design the underground structure so that an above ground building can be built over it and extended laterally to the sides.
- (c) Expansion can take place in the above ground building, so the size of the initial underground structure can be minimized to serve only the hardened routes that are scheduled through it. Forecasts of sideleg connections and other requirements not part of the through - route have been less accurate than those involving main route equipment. Thus, the difficult to forecast installations can be placed in the less expensive and less difficult to expand part of the building.

C. Power Feed Buildings on Coaxial Cable Routes

4.05 In the past power feed buildings were hardened underground structures of 10 or 50 PSI design. Power feed buildings are

normally unmanned and do not require radiation protection. A standard above ground 2 PSI power feed building as shown in Figure 4 has been designed for future coaxial cable routes. Survivable routes should be selected so far as economically possible to avoid the need to construct hardened underground power feed buildings. Where existing coaxial cable routes are scheduled for conversion and survivability is required, power feed buildings are to be constructed to withstand the expected nuclear overpressures for the respective sites.

D. Unattended Radio Relay Buildings

4.06 Radio relay buildings located on survivable corridor routes are to be built to 2 PSI hardness or less depending on the expected nuclear overpressure at the selected site. Avoidance measures are usually not economically restrictive and sites can usually be found that conform to these criteria. If the expected overpressure is 1/2 PSI or less, new buildings and major additions to existing buildings may be of concrete block or other suitable construction if substantial savings can be realized. Where overpressures are expected to exceed 1/2 PSI but not 2 PSI, new buildings and major additions to existing buildings in this environment should be designed to resist blast in the order of 2 PSI. Figure 5 shows a typical 2 PSI unattended radio relay building.

E. Special Hardening Devices

4.07 All survivable buildings require certain special hardening devices for the protection of equipment. The following broad guidelines indicate the types of devices required at the stated overpressures.

<u>Expected Nuclear Overpressure</u>	<u>Hardening Device Required</u>
2 PSI	- Blast closure devices at all openings (can be blast activated) - Hard mounted equipment
10 PSI	- Blast closure devices at all openings (can be blast activated) - Hard mounted equipment - Framing adequately braced - Blast door at entrance

Expected
Nuclear
Overpressure

Hardening
Device
Required

50 PSI

- Blast closure devices at all openings (automatic with outlying sensors).
- Shock mounted equipment
- Framing adequately braced
- Blast door at entrance

4.08 Earthquake bracing may be required in addition to any special measures taken for nuclear blast effects. This requirement is currently being reviewed by Long Lines Engineering and the Bell Laboratories. It is anticipated that buildings located in regions with a high probability of earthquake will require special bracing to meet this threat. This bracing must be compatible with the overpressures expected at the installation points.

F. EMP Protection

4.09 EMP is a possible threat to nearly all communications equipment. Under the proper circumstances, a significant portion of the energy released during a nuclear detonation appears as an electro-Magnetic pulse (hence EMP). Two properties of EMP are significant, 1.) its extremely great range - up to 3000 miles from the site of detonation and 2.) the fact that EMP can cause disruption or damage when other weapon effects such as radiation, blast, thermal, debris, etc. are all absent. A high yield nuclear weapon, burst above the atmosphere, might disrupt communications over a large area of the U.S. without regard to specific targeting. The range of EMP is greatly diminished if the weapon is detonated within the atmosphere, therefore, EMP is not considered the dominant threat from an intra-atmospheric burst. EMP, therefore, if used as a weapon, would target mainly communications and other electronic equipment. Any point in the U.S., regardless of its proximity to a military target area, is susceptible to the maximum threat.

EMP causes damage by inducing transient currents into objects acting as a receiving antenna. These include telephone and power cables, radio towers, cable racks, distributing frames, wiring, etc. Solid state devices

are particularly sensitive to these transient currents. Some are large enough to cause the breakdown of dielectric material.

4.10 There are two methods by which EMP can penetrate a building. These are "direct" and "penetrators". Currents induced by either method add together. A summary of each type is contained herein, however, a more detailed explanation of this threat and protection measures to take is to be included in a Bell Laboratories handbook scheduled to be published before the end of 1974.

1. "Direct"

The EMP can penetrate the walls and roof of a building direct. The amounts of attenuation to the pulse when passing through the building depends on the type of building construction. A hardened building of 2 PSI construction or greater generally has sufficient density and steel reinforcement to attenuate EMP to a harmless level.

2. "Penetrators"

EMP will induce relatively large currents in cables - both underground and aerial, power lines, radio towers, and waveguides. These currents are carried through building walls and in highly shielded buildings, become the dominant source of transient currents that cause damage. Protection against EMP "penetrators" is obtained by:

- a. Grounding of cable sheaths at or adjacent to the building wall.
- b. Carbon protectors adjacent to the building wall on all communication cable conductors.
- c. Proper secondary and tertiary lightning protectors on AC power.
- d. Proper grounding of waveguide and waveguide ports to the peripheral and ring grounding system.

G. Radiation Protection at Manned Buildings

4.11 Survivable buildings that are attended by people to perform essential work operations must be constructed to provide fallout protection. In addition to sufficient

mass to attenuate radiation to acceptable levels, other measures such as high efficiency air filters for filtering out dangerous radiation will be required where air intake openings are present (e.g., intake systems and air conditioning).

4.12 The threat of a chemical or bacteriological attack is considered to have diminished to such an extent that it is no longer advisable to provide costly protective measures, such as the CBR filter system, against these agents.

H. Emergency Fuel Supplies

4.13 If a nuclear attack occurred in a relatively short time span, a total period of two weeks is expected to suffice for radiation protection, but transportation and refueling problems, especially in rural areas, makes it desirable to have a 21 day fuel and lubricating oil supply at all buildings located on the survivable corridor routes.

I. Emergency Food and Safe Water

4.14 In buildings where people will be required to perform work operations during and following a nuclear attack, arrangements for emergency food, safe water and other necessities are to be provided. Since the survivable buildings are usually located in rural areas, where resupply might be difficult, supplies should be provided for 21 days.

5. Sidelegs into Metropolitan Areas

A. General

5.01 Sidelegs serving cities may be soft in keeping with the installations served. If a city is subjected to blast during a nuclear attack, it is expected that sidelegs would be lost for service in addition to the populace which they are designed to serve.

B. Switching Buildings in Cities

5.02 Switching buildings handling through services are generally located in metropolitan areas which are likely to be potential targets. These buildings are not to be designed to withstand collateral damage from a nuclear blast. However, there is the likelihood that the area will not be targeted and the principal concern, in such an event, is that protection against radioactive fallout be available for personnel who must remain there to operate essential communications equipment for through services. Conventional construction can be used for all other areas of these buildings. Figure 6 shows a Long Lines switching building in a large city.

5.03 In general, it is expected that radioactive fallout would make outside movement and resupply impossible for a period of about two weeks. Therefore, in addition to fallout protection, emergency food and safe water must be supplied to support personnel handling through requirements for a period of 14 days.

5.04 Under nuclear attack it is expected that a prolonged failure of commercial power will occur, necessitating the provision of fuel and lubrication supplies to permit emergency engine - alternators to operate for 14 days without supply. We foresee no need for fuel supplies beyond those dictated by local delivery capabilities if fundamental plans show only terminal requirements for the entire life of the building. Where there is the possibility of a terminal building being used for through requirements at some later date, provision should be made to permit going to a 14 day fuel supply at that time for handling through route requirements only. Some economies in fuel storage can be achieved if through requirements can be isolated from terminal requirements. We also recommend this alternative be studied in those cases where space for fuel storage presents a physical problem.

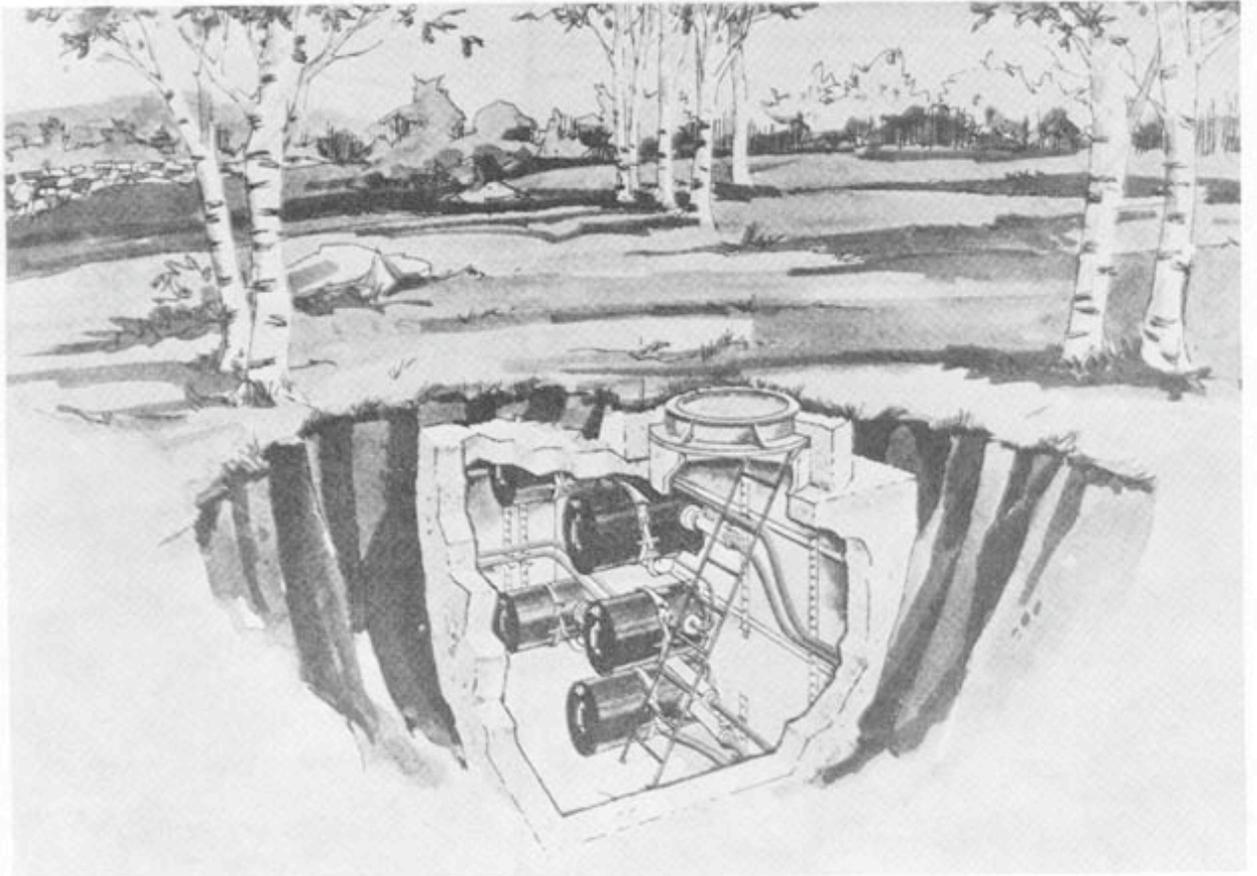


Fig. 1 - Cutaway View of Hardened Underground L4
Coaxial Auxiliary Repeater Structure

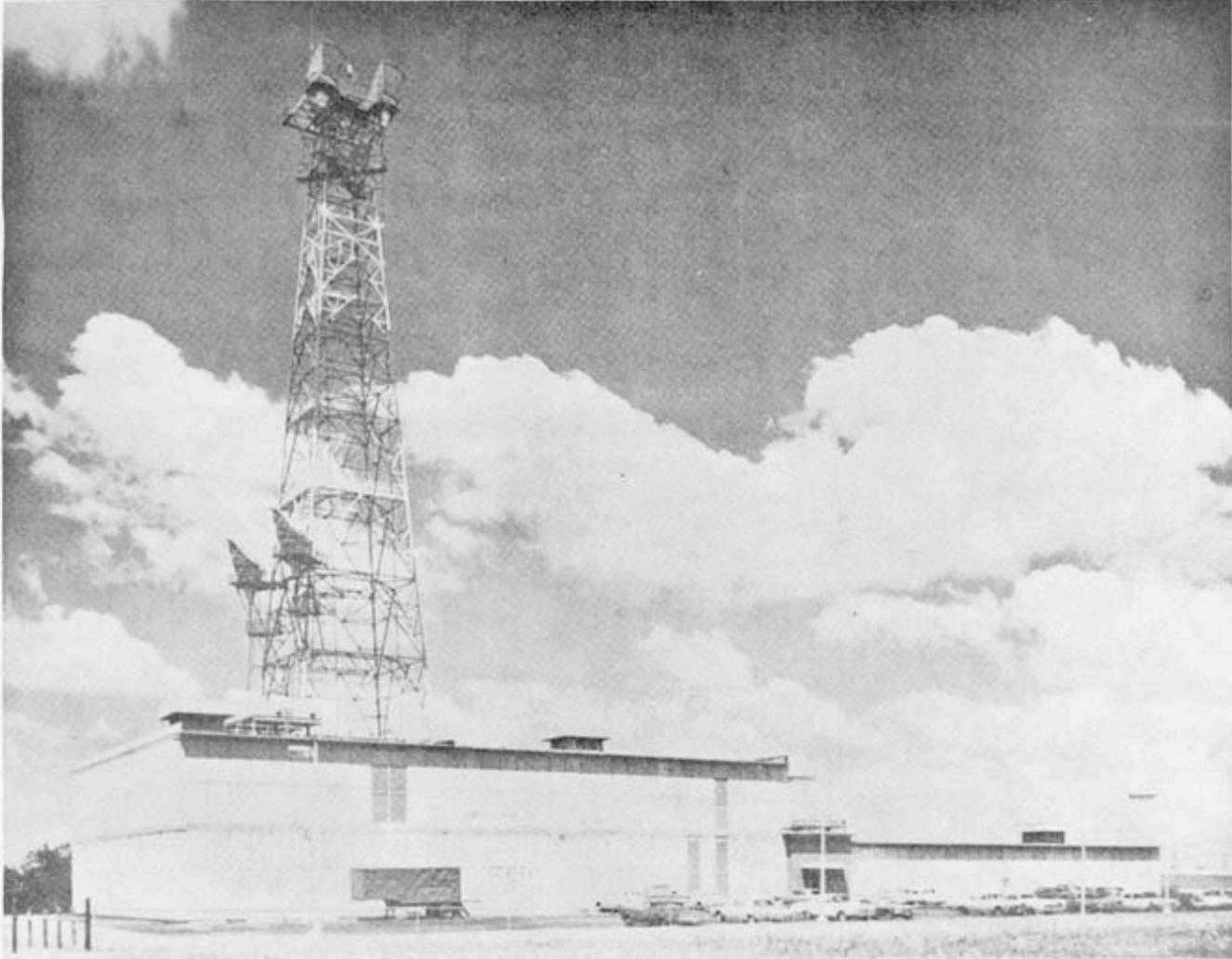


Fig. 2 - Typical Above Ground Main
Junction Building

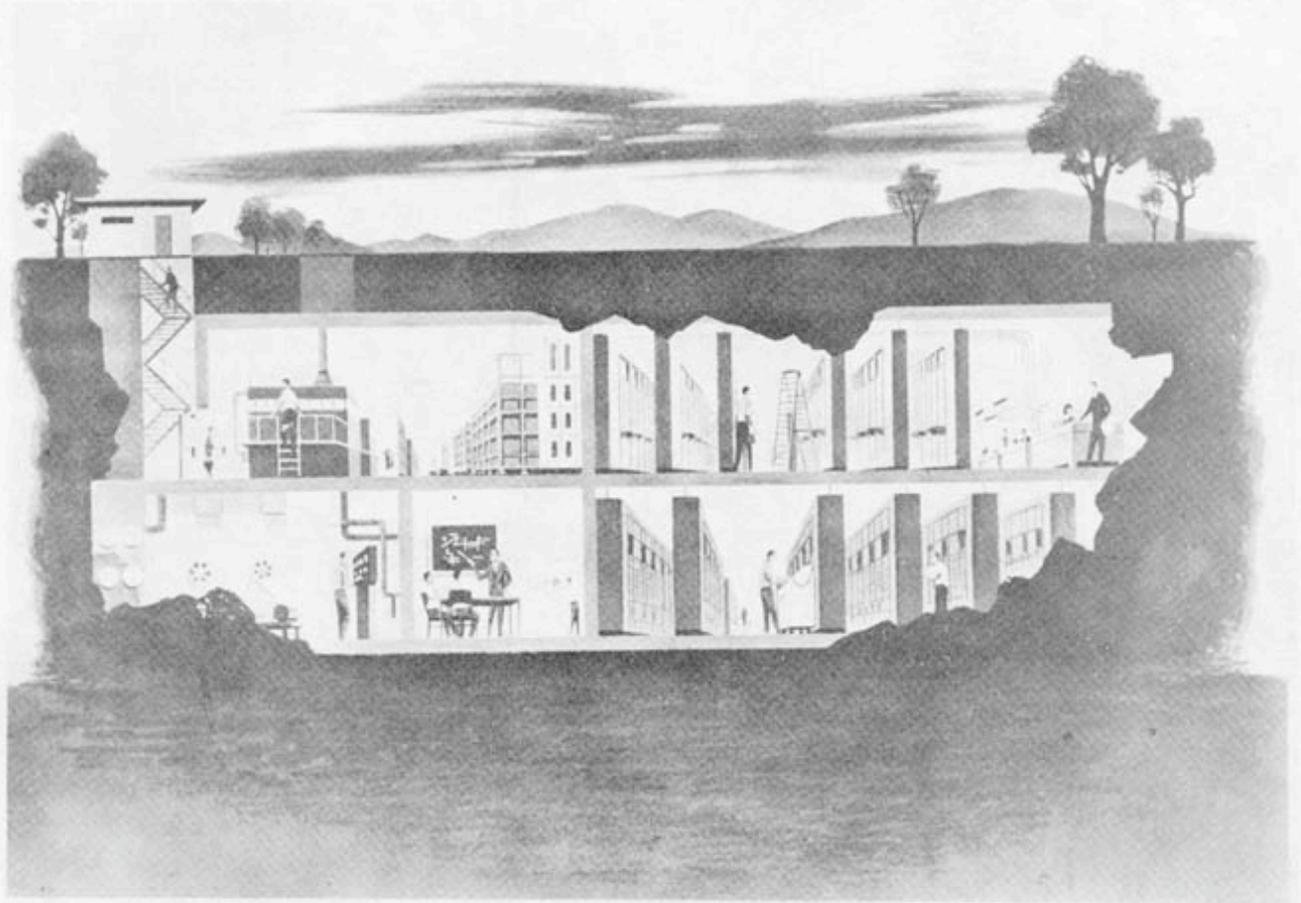


Fig. 3 - Cutaway View of Hardened Underground
Main Junction or Power Feed Station

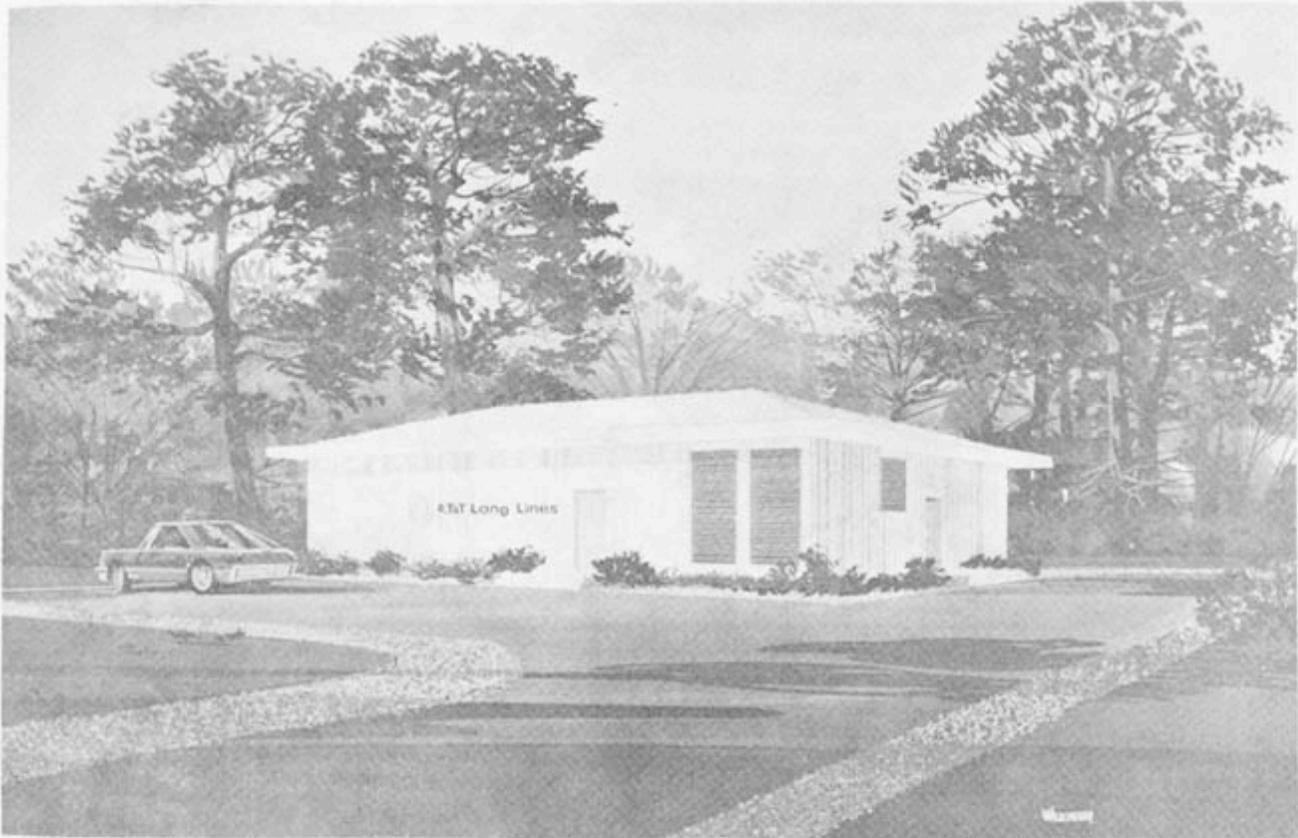


Fig. 4 - Standard 2PSI Above Ground
L5 Power Feed Station



Fig. 5 - Typical 2PSI Auxiliary Radio
Relay Building

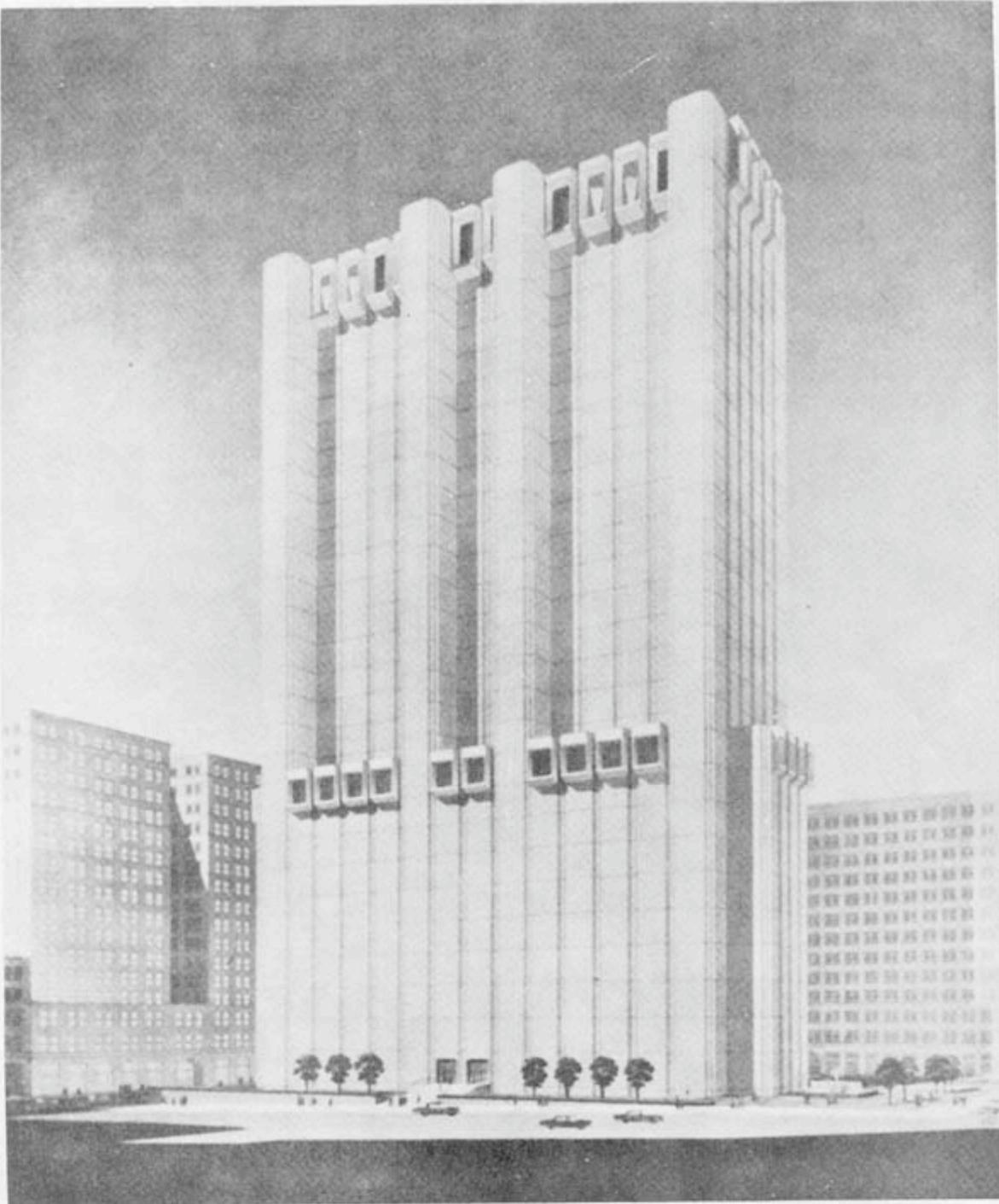


Fig. 6 - Switching Building in Large City (Artist Conception of 323 Broadway Building, New York City)