# URBAN SCALE VULNERABILITY:

# SOME IMPLICATIONS FOR PLANNING

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## Introduction: The Mandates and Imperatives of Earthquake Hazard Mitigation

The notion of intervention in the environment to mitigate the consequences of disasters--in the specific instances earthquakes--implies the use of fundamental government powers to manipulate environmental change towards the goal of achieving public safety. The question in a comparative context is what are the mandates and/or imperatives that emerge relating to institutional, political, or even cultural determinants. Secondly, as it is premised on the ability to wield these powers, what is the function of planning in this milieu?

The powers which sovereign bodies can bring to bear on disaster mitigation might be characterized as coercive on the one hand and permissive on the other. Numerous precedents exist for the use of coercive measures, or those leading to regulation by public bodies, to influence environmental change which may be useful in a pre- or post-earthquake situation. Land use regulations, such as zoning and subdivision ordinances, are now extensively utilized. These mechanisms were first employed only as a means of preventing problems arising from the juxtaposition of noxious uses, but later as a means of promoting the development of amenities. As this exemplifies, applications of police powers are dynamic.

In fact, as the understanding of environmental complexity becomes more sophisticated, the network of regulations to deal with it has become correspondingly more detailed. As a case in point, the 1969 Environmental Policy Act of the United States requiring impact statements for federal actions which have a "direct and significant" impact on the environment, is neither regulation per se nor an incentive per se, but an instance of institutionalized evaluation. By examining a proposed action for its impact--including adverse effects, feasible alternatives, long and short term applications--the assessment is relying on a <u>systematic and selective predictive process</u>. The relevance for hazard mitigation is obvious. As Andrews noted, the "process of planning is shot through from start to finish with judgments, intuitive predictions and assumptions about the impacts of alternative actions" [Andrews, 1975]. Coastal management planning which in and of itself is a voluntary national program precipitated by the Coastal Zone Management Act of 1972, requires that those states which choose to take federal money to develop a plan include an assessment of natural hazards in the coastal zone [The Conservation Foundation, 1980].

Precedents also exist for the use of permissive measures to achieve planning goals using incentives between and among levels of government. The national flood insurance program requires states to identify and employ development controls in floodplains in order to be eligible for national insurance, an approach which may have application in known fault zones or areas of severe ground instability. Requirements for the disclosure of hazard information in real estate transactions have been adopted in some states which then rely on the public to act in accord with the information [Kockelman, 1981]. Public education and information programs, like the State of Texas' Hurricane Awareness Program, assume the knowledge of risk provides incentive for action, whether it be for financial or personal safety reasons, although skepticism remains regarding the efficacy of such an approach. Financial incentives in general, provided primarily through the federal government, often motivate state and local governments to undertake planning programs such as coastal zone management, water quality planning or even research in the area of hazard mitigation. Although the U.S. is a federated country, the ostensible allocation of power is deceptive. For example, the dual coercive and incentive efforts of the tax power are well known, and federal, state and local government policies and programs have significant effects on investment, development and the resultant urban scene.

## Urban Planning: Changing Views of the Planning Process

Before looking at earthquake hazard mitigation as a planning issue, the word "planning" must be explored. Broadly speaking, planning is an approach to problem solving; it is a process for making informed decisions about the future. But since its inception as a profession applied to the urban environment, the scope and method of planning have been the subject of continuing debate. From planning's early focus on civic design and municipal order, there was an emphasis on product. Underlying the notion of a general plan was the implicit assumption that problems and relationships could be precisely defined in physical terms; therefore the master plan identified physical relationships betweenland uses projected to a future point in time. Community decisions, such as capital expenditures or public regulatory measures, would deliberately follow from the plan. This physically deterministic perspective was intrinsically static. Much of the ensuing planning enabling legislation reflected this predisposition.

This determinist view is now held to be an untenable model of how a city functions, and the concept of planning as a dynamic if not comprehensive process has taken its place. The newer outlooks on planning emphasize the development of general goals statements and the recognition of informational feedback and iterations. Physical planning is coupled with policy and program planning where there is deliberation on goals, development of alternative physical or policy configurations related to those goals, and consideration of implementation through specific action programs. The process approach also recognizes the need for continuing adjustment to reflect changing circumstances. Significant, too, is the fact that the scope of planning expanded far beyond physical land use relationships. Problems caused by urban growth and resource development and a more sophisticated understanding of urban decision-making dynamics have led planners to consider growth management approaches and more sophisticated views of economic development; environmental quality; energy and resource conservation; historic preservation; and health, education, and welfare programs among others [American Planning Association].

Although the American Planning Association now defines planning as a "comprehensive, coordinated and continuing process," theoreticians debate whether planning can be truly comprehensive or remains relegated to the incremental [APA, 1979]. Indeed, social pressures have given rise to the advocates of "advocacy" planning, i.e., participation of pressure groups who have hithertofore been closed out of the decision-making stream of public action. Furthermore, in doing planning, many state and local governments operate from the basis of legislation that is premised on a static general plan model. There is a dilemma inherent in the process definition of planning, however. Local plans must be reliable and predictable guides for public and private community development decisions, particularly since litigation in the courts seeks precise description and analyses insofar as can be developed. Therefore, plans balance a degree of stasis with the need to recognize that they are part of an ongoing process. Consequently, in the absence of visionary guidance, most local governments prepare <u>plans</u>.

Since urban planning is an exercise of the police power which was generally reserved to the states when the Constitution of the United States was drafted, the federal role in overt planning is restricted to providing incentives, and usually those incentives have been monetary. American cities have relied to a large degree on federal programs to support comprehensive community planning and urban development programs. Programs administered by the Department of Housing and Urban Development, such as Comprehensive Planning Assistance 701, Community Block Grant and Community Development Block Grants have been the mainstays of comprehensive city planning. In recent years, other incentive programs have been institutionalized, reflecting the broadening scope of planning. For example, funding is available to support economic development planning through the Economic Development Administration; the Environmental Protection Agency's 208 planning grants provide funds for water quality planning, and the Office of Coastal Management provides funds to support comprehensive planning in the coastal zone. As an additional incentive, federal agencies agree to act in accordance with an approved state coastal management program.

They hold the purse strings, so federal agencies have a great deal of influence over the planning that is done across the nation; and in most cases, state and local planning follow the federal lead. Thus, in spite of the "Earthquake Hazards Reduction Act of 1977" (Public Law 97-124) which is aimed at reducing risks to life and property, the act focuses on action at the federal level and does not include any direct incentives for states to engage in hazard mitigation planning. Since the federal government is usually called in to bail out areas hit by large-scale disasters, it is surprising that planning incentives were not incorporated. In the absence of an incentive to plan for earthquakes as well as the absence of a sense of risk, few state or local governments have adopted planning as a means to mitigate earthquake hazards.[1]

## Urban Planning: Earthquake Hazard Mitigation in California--An Example

To exemplify the American approach to planning in general and seismic hazard mitigation specifically, the State of California will be used.[2] Although it may not be at the zenith or nadir of American planning practice, California probably represents the state-of-the-art in its approach to earthquake hazard mitigation.

California is unusual in that since 1955 it has required county and city governments to adopt a general plan (Government Code Sections 65300 et seq.).[3] In addition to requiring local governments to prepare and adopt a general plan, zoning and subdivision ordinances were required to be consistent with the plan after 1971. Following the 1971 San Fernando earthquake which took 64 lives and caused over $500 million in property damage, the California legislature passed a bill requiring local governments to add a seismic element to county and city general plans as a means of reducing losses of life, property damage, and other social or economic disruptions as a result of earthquakes. Each plan must include at a minimum all of the following elements: land use, circulation, housing, conservation, open space, seismic safety, noise, scenic highway, and safety. Required to contain data and analysis, policies, and an implementation program, the seismic element must specifically include: "an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to effects of seismically induced waves such as tsunamis or seiches" (emphasis added) (Government Code 65302(f)). Mudslides, landslides, slope stability and other hazards are also to be considered. The 1980 draft General Plan Guidelines further state: "The seismic safety element is primarily a vehicle for identifying hazards that must be considered in planning the location, type, and density of development" (emphasis added) [Office of Planning and Research, 1980]. State guidelines thus give local governments latitude in determining how the identification and appraisal of hazards will be reflected in land use decision-making. Indeed, California's approach apparently relies upon structural soundness and building restriction in specified hazard zones as the major means for promoting seismic safety. Although there is no mandatory state planning review and approval process, cities and counties must submit their seismic safety elements and any related technical studies to the State Division of Mines and Geology (Government Code Section 65302(f)).

Oakland, California, a large city on San Francisco Bay which sits astride traces of the Hayward Fault, is typical of cities in the most seismically active part of the state. Its Environmental Hazards element, combining the seismic and safety requirements, is also representative of how local governments approach earthquake mitigation. The document contains four essential parts [City of Oakland, 1974]:

1. The Environmental Hazard Identification section technically describes and maps the history and current status of the various hazards as specified in the code, but at a gross scale. It also predicts some urban development implications of these hazards.

2. Structural Hazard Identification. The plan identifies areas where the potential for structural or facility damage is high. It identifies by census tract where there are concentrations of residential structures containing three or more units; of those, which dwellings were built before 1939 (date the earthquake resistant building code was instituted); number of commercial and industrial masonry buildings built before 1940; and the location of several critical facilities: schools, hospitals and fire stations. The vulnerability of utility and transporation facilities is acknowledged and the existence of stricter development standards with back-systems are noted.

3. Hazard Prone Areas. Based on analysis of the previous data, general hazard prone areas are isolated, and hazards specific to each area are described, including structural hazards, special studies zones (faulting), poor ground response, and other non-seismic hazards.

4. Policies and Programs. The policies and programs attempt to prevent the creation of new risks and eventually eliminate existing ones. To that end, programs emphasize information dissemination, hazard identification, siting key facilities and other buildings away from identified fault zones, and enforcing codes for new and old buildings.

Like Oakland, most other seismic elements for California cities stress structural safety or development setbacks near known faults. For example, a 1969 San Francisco ordinance, seldom enforced, required the removal or strengthening of unsafe parapets or building appendages [Blair, et al., 1979] and [Lu, 1978]. San Jose has identified seven ground-response zones where ground-shaking may cause serious damage to certain types of structures [Blair, et al., 1979]. Portola Valley has adopted building setbacks along known fault traces as well as hired a town geologist to review building permits, supervise town geologic mapping, and advise on General Plan amendments [Mader, et al., 1972].

To generalize from California's experience, the focus of mitigation to date has been on: (1) hazard identification and location, (2) building and structural soundness, and (3) development of setbacks--especially for critical facilities--near known faults. Facilities such as communication lines, roads, water and services are acknowledged to be susceptible to damage, but this has yet to be approached from a planning perspective.

There is yet a need to step back and look at the urban scale, that is, how the town morphology and physical form and activity patterns impinge upon urban vulnerability.

Urban Planning and Urban Scale Vulnerability--A Model

The general subject area here emphasizes the preventative. This does not preclude attention to or evaluation of detailed seismic damage to individual buildings or other facilities, but there is an additional task of anticipation, or planning, for alternative spatial and regional considerations given the potential for earthquake disasters. In so doing, however, the preparatory and remedial are not set aside, but should be considered implicit in anticipating some key factors that contribute to recovery if and when earthquakes strike. It is the nature of planning to pose alternatives and to evaluate and compare their respective consequences, but this does not seem to be incorporated into the experience or literature of disaster mitigation at the urban scale. The following proposes to isolate out significant elements and factors for study at several scales, noting the comparative issues, and then test whether these fundamentals are reflected in current planning practice.

Any effort that compares, presumably compares similarities and differences, so that the immediate problem is to abstract out the internal and external variables that pertain to the general scene or to specifically designated study areas selected for comparison. Therefore, the additional intent here is to: (a) pinpoint problems, issues, or areas for comparison and (b) construct a more abstract, or prototypical, model to compare to, while (c) suggesting methodologies for the use of proxy or surrogate measures for comparison. For planners, this implies considering systems of operation or hierarachical frameworks before focusing on the specifics.

Scale is to be considered a major issue. "Urban scale" vulnerability in this case may be conceived in both macro and micro terms. The principal concern is the context, that is where, when, and how the disaster takes place given the constraints, possibilities, and probabilities of the preventative or remedial actions that would occur. It should be emphasized, however, that territorial scale, or "where" is crucial.

The urban scale can be broken down into regions, city-wide areas, and city sectors. Although such words are ambiguous, for purposes here the area under examination encompasses a city center plus the area surrounding it that affects and is affected by the daily rhythms of urban regional life. Without differentiating between rural vs. urban or dense vs. scattered development, such an area could be construed to mean centers and subcenters encircled by a number of overlapping employment, recreational, housing, and various service or catchment areas.

Distinguishing between macro and micro analyses, it is hypothesized that the macro urban settlement form and pattern[4] may be broken down into: (1) density and land use intensity patterns; (2) regional nodes and focal points, or the centers and subcenters of urban activity; and (3) the lines of accessibility, communication, and transportation, considering the systems of interaction, points of clustering and focusing, and fields of "traffic" generation. What should be sought is a diagrammatic portrayal of macro-scale development or redevelopment as shaped by economic intervention and socio/political factors.

Then, given the above contextual framework, micro analyses follow. The "micro" scale, as such could be construed as a residential neighborhood with its ancillary shopping facilities, schools and recreation areas. The same generics of macro scale examinations as described above apply here, but the scales - or level of dimension, texture or activity - are different. Basically, the immediate locale should be viewed within the city sector and the city region, conceptualizing the micro problem in a macro setting, but with each "zone" differentiated by measurement or evaluation characteristics. At the micro scale, there may be surveys of building groups and their existing conditions, particularly in areas of potential change or damage. It might also be relevant to examine the adaptive reuse potential of certain structures with the possibility of emphasizing inherent differences in past building practices in a sector of a city.

Before describing a hypothetical urban scale vulnerability model for use in a comparative context, two bases of comparison must be defined: the homological and the analogical. In urban and regional planning terms, the first means comparison of"a" or "the" plan for action, whereas the other emphasizes the "planning", or the process out of which a plan emerges. One contemplates a product and the other, a process. Planners must do both, but at varying scales in various places at various times.

Given, therefore, that planners are concerned with systems and interactions within macro and micro spheres of urban environments, the underpinnings of earthquake hazard mitigation must be examined apropos the foregoing. While much of the work to date has been directed towards the avoidance of structural failure of individual buildings, it is recognized that the secondary effects of urban systems failure may cause equal or even greater disruption to the urban equilibrium than specific, direct losses [Krimgold, n.d.]. Fires in the absense of a functioning water system can decimate a city reeling from a quake; transportation system failure can frustrate both rescue and long-term recovery. In addition, on a more intimate scale, the disruption of community and individual activity patterns can have longer term social, psychological and economic ramifications. Due to their nature, lifeline facilities and other network systems are certainly susceptible to earthquake disruption; moreover, because they function as a network, the failure of one element or one segment of the system can impair the function of the entire system [Krimgold, n.d.].

At the risk of oversimplification, an earthquake disrupts a physical system consisting of four major elements common to any urban environment, each of which is an integral to the whole. Therefore, disequilibrium induced in one will have ramifications for all the others. Although the distinctions blur at the edges, the four include: the urban artifact itself; the spatial dimension; an activity element; and a time element.[5]

1. The urban artifact consists of all the man-made structures and systems in the environment, including buildings and lifeline systems. Also subsumed here are considerations of land use density and

intensity, age and technology of development, types of construction, materials used, existing conditions, and the like.

2. The spatial dimension is concerned with the location of these artifacts in the physical environment--the morphology of the place--as characterized by form, spatial relationships, distribution, linkages, custom, and socio-economic forces as well as geophysical characteristics. It also includes the spatial ecology of urban residents, especially of critical groups such as the elderly, ill or the young.

3. The activity element includes the types of activities that take place in the environment--work, shop, play, rest, etc.--and look at their distribution, density configurations, and their relationship to the urban artifact.

4. Finally, the time element examines the temporal and seasonal aspects of the macro-region, recording the "pulse" of activities in time and at places. Changes in the "configuration" of these elements obviously can make a significant difference in urban scale vulnerability.[6]

The forthcoming model thus serves two purposes. First, it sets forth those elements which an earthquake mitigation strategy must address, and second, it provides a basis for comparability with other countries.

There are however two other realms that also have critical implications for earthquake hazard mitigation. The first is so obvious it only needs a passing mention here, and that is knowledge of the underlying geology of an urban area. Nevertheless, in spite of the central role it should play as the grounding for hazard mitigation, many planning agencies have shortcut this category of data collection, and in addition, planning professionals frequently do not know how to use the information if it is available.

The other realm is the overriding political decision-making system which is responsible for carrying out policies, plans, and programs. The physical environmental elements and systems are governed and managed by a complex network of federal, state, and local government agencies and private sector players. Coordination among jurisdictions, agencies and governments is essential to avoid delays, ineffective responses, and ineffectively coordinated support delivery in the event there is a catastrophic earthquake. Not only is this coordination essential to respond to a disaster, it is also essential if preparation is to be successful in mitigating the hazard. International comparisons of the organization framework to deal with disasters would also be instructive.

Thus, when addressing the issue of urban scale vulnerability to earthquake hazards from a planning perspective, the problem goes beyond public safety, least cost, and workability alone. Clearly, it becomes a matter of perception and analysis of the continuum extending from public policy actions to the achievement of community goals in a three-dimensional built or rebuilt environment. As the urban form represents the physical result of the exogenous forces embodied in public and private policy decisions, these physical outcomes must be seen in an interrelated context. Applying this logic to the issue of earthquakes implies that attention to structures or lifeline systems alone ignores the contextual issues and is therefore inadequate.

Using the model, some areas for comparison fall out:

1. The age and pace of development in selected geographic areas and the "appropriate technology" that was or was not traditionally used, and thus its consequent vulnerability. The types of construction should be a significant issue here as well.

2. The morphology of development as characterized by time, custom, socio-economic forces, and geophysical characteristics.

3. Regionalism and political decision-making. For example, what impacts do the historical as well as existing patterns of unitary vs. federated forms of government have on regulations, appropriations, and the like? (Italy represents a more unitary form of government, Yugoslavia is quite federated, while the U.S. is, comparatively at least, somewhere in between.)

These three are only gross examples of what could be considered proxy measures for international comparison that will serve as indicators of political, social, physical, and economic history.[7]

Urban Planning and Urban Scale Vulnerability--The Model Tested in Oakland

The assumption has been made in this paper that the foregoing is a reasonable model of an appropriate planning framework for evaluating urban scale vulnerability. Taking this somewhat abstract model, it may be valuable to return to Oakland's seismic element to assess the scope of planning in one of the U.S.'s most seismically sophisticated states. As an initial caveat, it should be mentioned that the analysis here is not meant to be exhaustive, rather it only highlights by key areas of coverage.

California's Government Code directs local jurisdictions to "identify and appraise" a variety of seismic hazards, which, in a summary fashion, the Oakland element does for generalized geology, known faults, susceptibility to ground shaking, and landslide potential. The mapping scale is gross, but at the same time, the general absence of precise geological information makes more detailed mapping somewhat specious and misleading.

Examination of the (1) urban artifact is limited to an overview of management structures with some attention to age, construction type, and building conditions. Density and intensity considerations as they may impinge upon vulnerability and recovery are absent. There is only a passing assessment of standards for urban infrastructure systems.

(2) Spatial dimensions -- while attention is paid to hazard location, the morphology and distribution of urban areas and activities are virtually ignored. The location of several critical facilities and certain seismically vulnerable structures represents the extent of

Oakland's attention to the complexity of the spatial aspects of vulnerability. But equally important are the relationships between the built environment and transportation, communication, and open space systems vis a vis the hazards, the location of activity nodes, special districts, and the like. A conspicuous omission is the absence of any consideration of system linkages and interactions. Earthquakes do not recognize political boundaries: while Oakland may not be physically damaged by an earthquake in San Francisco, secondary impacts on transportation, communication, flow of goods, and the general economy could be severe.

(3) The Oakland element does not examine the vulnerability of various activities and activity centers other than several critical facilities. For example, what might the implications be for a disaster occuring during work hours or rush hours vs. a major sporting event in terms of public safety, rescue, or short- or long-term recovery?

(4) Temporal or seasonal considerations are also overlooked, although it is well-known that the coincidence of the factors of time, season, and activity can significantly effect the extent of loss and the difficulty of recovery, i.e., emergency shelter in the middle of winter entails a different set of requirements than during the summer.

Oakland's implementation system relies upon codes and ordinances addressing structural soundness and the location of certain structures with respect to known hazardous areas. It recommends developing criteria or regulations for streets, utilities, transmission lines and other facilities which may traverse hazard areas, but again the focus is on structural integrity of the individual systems, not the overall pattern of the utility network and its response to disaster. Since utilities and transportation systems themselves influence the morphology of urban growth, it is essential that earthquake hazard mitigation expand its definition of the scope of the problem.

The plan acknowledges that the city has yet to identify the level of "Acceptable Risk"--or that point below which no specific local government action is deemed necessary, that is where costs, both economic and social, outweigh the value of minimized hazards. As a study which identifies and locates the hazards, discusses potential consequences, and provides information, the Oakland Environmental Hazards Element represents a step toward that end.

The City's Emergency Operations Plan, adopted in 1973 to conform to the previously mentioned federal mandate for such plans, has the stated purpose of providing governmental continuity, providing emergency services, restoring essential systems and services, and coordinating with Emergency Services organizations of other jurisdictions in the event of a significant disaster. Although the sufficiency of this emergency plan is not examined here, in 1980 the Federal Emergency Management Agency evaluated California's readiness to cope with the effects of a catastrophic earthquake. They concluded: "While current response plans and preparedness measures may be adequate for moderate earthquakes, federal, state, and local officials agree that preparations are woefully inadequate to cope with the damage and casualties from a catastrophic earthquake, and with the disruptions in communications, social fabric, and governmental structure that may follow" [FEMA, 1980]. Coordination among overlapping jurisdictions, agencies, and levels of government dealing with the panoply of urban systems and services affected by an earthquake was also found to be inadequate. As a case in point, Oakland's Emergency Operations Plan is apparently not integrated into an earthquake mitigation decision-making continuum, but considered apart from land use planning approaches.

In summing up, California's code and guidelines ask for little more than an identification of seismic hazards. There is no quality control or approval process required for the elements (although they are submitted to the California State Division of Mines and Geology), nor do the guidelines provide direction on what additionally should be addressed. In view of the fact that California may be America's most sophisticated state in dealing with earthquakes and Oakland a typical example of a local government's approach, the absence of a well-developed concept of urban scale vulnerability in the United States becomes apparent.

Applications and Directions

Planners and urban designers could examine the possibilities of developing an "urban vulnerability index" which incorporates the variety of vulnerability determinants that have been previously mentioned--from geologic data; land use type, intensity and density; structural form, age, material, and size; spatial configurations; lines of access and services; general morphology; activity patterns; time envelopes; seasonal dimensions; to the magnitude of the event and others. Such a system could be particularly versatile if it were computerized to facilitate the development and execution of numerous scenarios and allow the manipulation of a variety of intervention or mitigation approaches. Since earthquakes will continue to be unpredictable events for some time to come, a vulnerability index would allow governments and individuals to target attention to those areas most in need of code enforcement, zoning changes, land use redistribution, restoration, or any of a number of alterations.

A more sophisticated vulnerability index should also factor in the economic and other costs of mitigation. In so doing, communities may develop a repertoire of mitigative responses that respond to safety, social, cultural, economic and political considerations and range from preparation, prevention to recovery. For example, in certain areas complete retrofitting or renewal may be economically infeasible and culturally, socially, and architecturally undesirable. The community may then be willing to accept a higher level of risk exposure, but balance that with a greater emphasis on preparation for disaster and recovery should an earthquake strike. Residents or other users of the area may be the subject of an unusually intensive information campaign, "safe areas" may be provided for gathering and refuge following a disaster, temporary housing could be stockpiled, and a rebuilding strategy could be developed ahead of time so that important cultural and social attributes would be retained and extreme hazardous conditions eliminated.

The questions for urban planners operating in an international comparative context therefore revolve around new probes into:

1. Land use planning and regulation in disaster impacted urban areas considering the urban morphology and examining the applicability of existing regulatory and incentive measures to disaster mitigation, including institutionalized impact analyses. In addition, the effects of changes in land use management and seismic zonation, zero-lotline housing, and downtown development can be compared.

2. The vulnerability and rebuilding problems of an urban pattern considering: (a) land use densities and intensities, (b) nodes of activities, or centers and sub-centers, (c) the accessibility system, and (d) the upgrading of existing structures.

3. Building typology guidelines which inventory the urban fabric and volumetric aspects of the extent and character of building groups, and develop classifications and evaluations of existing buildings along with methods of documentation and assessment. Respective international experiences in developing and applying various technical methods can be investigated, such as the Yugoslavian and Italian expertise in assessing and documenting their built environment and the American experiments with remote sensing, computerized as built drawings, and computerized geo-based information systems.

4. Systems analysis of activity patterns, and the primary, secondary, and tertiary impacts of disruption.

5. Emergency planning and the continuum of hazard mitigation strategies for a range of earthquake magnitudes.

6. Preparation of risk and vulnerability maps, incorporating time and tempo of urban activities and networking of service areas. Defining "acceptable risk" at the urban scale should be considered here.

## FOOTNOTES

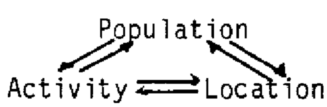
1. States are required to have Emergency Preparedness Plans as a result of the "Disaster Relief Act of 1974" (Public Law 93-288), but are not required to have hazard mitigation plans.

2. It should be noted that this paper relies almost exclusively upon American examples to illustrate key points, but it does so within a framework that is designed to accommodate extrapolations to the international scene.

3. All states have planning enabling legislation, but fewer require local jurisdictions to adopt plans, and fewer still specify their content by means of required elements.

4. For exemplification of the use of proxy measures as described above and for comparative purposes, "land use intensity" relates to activity per unit area (not "density" *per se*) and involves considerations of: (1) quality - measurements of, say, volumes of traffic generated within given land use areas, (2) time shape, or the variations in such traffic, (3) zones of influence - hard or soft edges of activity areas, service or catchment areas, etc., (4) material effects - sensory perceptions of noise, odor, mass, bulk, opacity - and the like [Modified from Guttenberg, 1959].

5. The implications here have been debated historically, extending from the works of those who have analyzed human activity patterns in space to those who have set up numerical models [ Lösch, 1945], and [Geddes, 1950 ] (Appendix 1, Part 2, details Geddes' extension of Frederick LePlay's "Place, Work and Folk"). The framework and the questions coming forth are:




   1. What is the population of an activity?
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   6. What is the location of an activity?

   (Indebted to Professor Barclay Jones and Charles R. Wolfe for this example.)

6. One example which spans several of the four elements will suffice to illustrate the general point here. Ugo Morelli points out that the severity of the recent Italian earthquake resulted from: (1) The season and the time of day, in that at 7:35 PM on a Sunday in November, most people were at home preparing dinner and watching a soccer match; (2) The age and morphology of the towns, reflected in the unreinforced masonry construction with roofs of heavy wooden beams and clay tiles. Here is where a comparison becomes interesting. As Morelli goes on to state, in the United States, most homes are of wood frame construction, making them resilient to earthquake damage and relatively safe refuges

in the event of an earthquake. Unreinforced masonry construction, on the other hand, is typical in Italian towns and prone to collapse from earthquake shaking. (3) The inability to muster aid quickly; thus questions of responsibility become as important as physical mobility [Morelli, 1981].

7. As a case in point, one can examine and compare how patterns of development, which might now be different, may be moving toward being similar. What are the experiences in formulating regulatory measures that tend to encourage recycling in an area where, historically, preservation has been going on, yet where conservation efforts are hampered by the development of outlying centers? A more pertinent question here is: given earthquake possibilities, what potential effects can be expected, what gross and fine alternatives exist for rebuilding and/or prevention? More pointedly, are the Yugoslav and/or Italian efforts at conservation of historic structures useful for comparison with the U.S. in this context? If not "historic", are the reuse potentials greater in those countries; are the regulatory measures more efficacious, but are our distribution (transportation) patterns more efficient? Given the necessity of rebuilding, what are the urban form implications within political, social and economic constraints that make countries similar in some ways but different in others?

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