DEPARTMENT OF DEFENSE
FREEDOM OF INFORMATION DIVISION
1155 DEFENSE PENTAGON
WASHINGTON, DC 20301-1155

Ref: 15-F-1529
April 5, 2024

Mr. John Greenewald, Jr.
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Dear Mr. Greenewald:

This is a final response to your July 3, 2015 Freedom of Information Act (FOIA) request, a copy of which is enclosed for your convenience. We received your request on July 20, 2015, and assigned it FOIA case number 15-F-1529. We ask that you use this number when referring to your request.

The Office of the Under Secretary of Defense for Policy, a component of the Office of the Secretary of Defense, conducted a search of their records systems and located the enclosed document, totaling 76 pages, determined to be responsive to your request. It has been determined that this document is appropriate for release in its entirety, without excision.

This constitutes a full grant of your request and closes your case file in this office. There are no assessable fees associated with this response.

Should you wish to inquire about mediation services, you may contact the OSD/JS FOIA Public Liaison, Toni Fuentes, at 571-372-0462, or by email at OSD.FOIALiaison@mail.mil. You may also contact the Office of Government Information Services (OGIS) at the National Archives and Records Administration to inquire about the FOIA mediation services they offer at 202-741-5770/1-877-684-6448 or email: ogis@nara.gov.

If you have any questions or concerns about the foregoing or about the processing of your request, please do not hesitate to contact the Action Officer assigned to your request, Daniel Mullin, at 571-372-0465 or daniel.r.mullin3.civ@mail.mil. Additionally, if you have concerns about service received by our office, please contact a member of our Leadership Team at 571-372-0498 or Toll Free at 866-574-4970.

Sincerely,

for Pamela Andrews
Stephanie L. Carr
Chief

Enclosures:
As stated

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MILITARY TECHNOLOGY AND THE SURVIVAL OF CITIES

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SPACE AND INFORMATION SYSTEMS DIVISION

BEDFORD, MASSACHUSETTS

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MILITARY TECHNOLOGY AND THE SURVIVAL OF CITIES

by

Clark C. Abt

A UNICORN Study Phase II Report

for

Directorate for Arms Control
Office of the Assistant Secretary of Defense
International Security Affairs
Washington, D. C.

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Prepared by

Strategic Studies Department
Space and Information Systems Division
Bedford, Massachusetts

MILITARY TECHNOLOGY AND THE SURVIVAL OF CITIES

Abstract

The effects of modern strategic weapons on urban-industri
are considered from the aspects of weapon technology, military s
and arms control considerations. The possibilities for active and
defenses against likely threats are evaluated, and the major altern
for unilateral means of reduction of war casualties and damage ar
sidered. Quantitative cost-benefit estimates are developed for th
alternatives, which include hardening, dispersal, active defenses
mixes of these. A degree of urban dispersal satisfying peacetime
sibility and offering peacetime utilities, together with fallout shel
is found to provide a solution superior in cost-effectiveness to bla
shelters and/or active defenses, although the latter are not neces
ruled out for strategic reasons. Some economic and social const
on urban dispersal are considered, together with means for maki
feasible.

MILITARY TECHNOLOGY AND THE SURVIVAL OF CITIES

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Clark C. Abt

1. INTRODUCTION

The entire Winter 1961 issue of Daedalus, the Journal of the American Academy of Arts and Sciences, was devoted to the subject of "The Future Metropolis." Distinguished professors discussed many of the political, economic, and social and technological influences emanating from and impinging upon the preser and future metropolis. If the intent of the issue was not to be comprehensive, it was at least to identify and deliberate the mos salient issues concerning contemporary cities. And yet, as if by common conspiratorial consent to psychological denial of what has been called "unthinkable" but is conceivably unavoidable, not a single contributor so much as mentioned the potential impact of the revolution in weapon technology on the survival of cities as viable socio-economic institutions. Perhaps the distinguished pr fessors did not care to consider what happened to Rotterdam, Coventry, London, Cologne, Mainz, Berlin, Hamburg, Tokyo, Kobe, Hiroshima, and Nagasaki less than a generation ago. Perhaps they have privately considered the problem and found no hope of soluti in the design of great cities. And yet we are obliged to examine seriously the question of the continued viability of a social

institution invested by hundreds of millions of human beings, if only to determine that we do not have the information, or the imagination, or the courage to find an answer.

This essay is concerned with the human survival value of cities in an age of plentiful weapons of mass destruction, as yet uncontrolled and not promising to be soon or easily eliminated by more mature forms of political control. It will discuss the affirmative and negative answers to the question: Have recent developements in military technology made cities obsolete?

In this essay we shall not burden the reader with Utopian visions of large-scale population redistributions within a few years' time, nor yet with the promise of general and complete disarmament within the readily forseeable future. We are interested here in a sober evaluation of the effects of unprecedented threats of destruction on the continued social viability of the city, and how it might practically be modified to diminish this threat. We begin with an unhappy awareness of the great cultural, social, political, and economic values that are realized primarily in urban society (being a sometime city boy ourselves), together with an equally unhappy knowledge of the unmitigated vulnerability of cities to total destruction by modern weapons. We would like best to have world peace and disarmament, but since such hopes are optimistic, we would like to see what measures might be taken to preserve the best of urban values in a period of protracted political and possibly military conflict. If these measures turn out to require the sacrifice of a portion of urban values for the sake of insuring the survival of the greater part, we shall

weigh that possibility also.

The discussion will concentrate on the military threat posed by contemporary weapons to city survival, the possibilities for active and passive defense of cities in their present forms, and alternative political, economic, and technological modificatio of cities that might improve their survivability. Secondary subst tive discussion will consider the non-military threats of the revo lutionary technology to the efficiency of cities as social institu tions, and how these are perturbed by the military factors. The objective is not to present a pet panacea to what is a most comple and possibly tragic problem, but rather to identify the most impor tant problems that evaded the attention of the Daedalus essayists in a manner sufficiently thoughtful and serious, so as to stimulat some overdue research into possible solutions.

2. HISTORICAL PERSPECTIVE

The dominant physical characteristic of cities, towns, and villages throughout recorded history is the concentrated location of human dwellings and associated activities such as government and, in the last few thousand years, industry. This obvious fact embodies the expression of a less obvious but widespread human awareness of the advantages of such urban concentration. Relatively little attention was given to the specific nature of these advantages by the historiand and philosophers until quite recent times, partly because of their complexity, and partly because of their multiplicity and obviousness. With the rise of the industrial revolution in the last 200 years, and the weapons revolution of the last 20 years, serious social disadvantages of urban concentration are becoming increasingly obvious. It may therefore be useful to place in very general historical perspective the predominant causes of and dangers to the urban concentrations we have called villages, towns, and cities. (I purposely avoid the term "community," since this is so often used to designate groupings of persons or activities independent of physical distribution in the urban-versus-rural sense, as, for example, the Christian Community, the Western Community, etc.)

The historical social utility of the city has been that of the market, the port, the fortress, and the court. The market, long before the Greek agora, probably developed into a spatially orient economic institution for the barter of goods and information at all major confluences of trade routes--however local these may have been.

Such transportation centers developed both at the confluence of over land trade routes as a result of favorable factors of terrain, natural flora and fauna, and the mutual stimuli of multi-cultural impingement and near favorable harbors, river deltas, or river crossings to form the physically more permanent ports. With the inevitable concentration of diverse human types and their physical and intellectual wealth at these geographical nodes, came the need for local order to protect life and property from indigenous crime and external invasion, conquest, and ravishment. The organizational device developed by the shrewder residents of the market and/or port areas to establish and maintain order was civil government. Civil government included at various stages of autocracy, monarchy, theocracy, aristocracy, oligarchy, and democracy the social institutions of the court, the temple, the forum, and the theater. The word court probably best summarizes the civil, juridical, religious, inspirational, political and entertainment values embodies in the organizational center of the historical city, although these aspects were often specialized and de-centralized. The physical device employed to protect the market port, and court from external invasion and upset was the fortress. The fortress served as an effective organizing concept for the concentration of military resources and administration, and as base and sanctuary for mobile expeditions by land and sea.

The development of cities as markets, ports, courts, and fortresses usually took place in the parallel, although one may discern a rough sequency from market to port to court/fortress most frequently. The court and the fortress had their flowering chiefly

in the last 3000 years. Impressive examples include the Athenian Acropolis, the French Carcassonne, The Iberian Granada, and the fortified peripheries of most of the medieval cities of Europe.

It is likely that the urban concentrations called towns and cities would have developed as a result of any one of the four formative utilities described above. If men lived in peaceful and cooperative Utopian anarchy with one another, not requiring fort or court, they would probably still seek meeting places at the convenient confluence of transportation routes for augmented cooperation and social intercourse. If by some magical means, men had always been capable of telekinesis and mental telepathy, but required physical defense, they might yet have piled up timber and rock to form fortresses. The new question is: Would men, will men, continue to build and live in urban concentrations, when such concentrations bring into essential conflict the politico-economic objectives with the military requirements for physical security?--And is this really the case?

3. MILITARY TECHNOLOGY THREATENS THE CITY

Even in World War II, before the employment of atomic bombs, the manned bomber aircraft using chemical high explosive bombs was capable of the complete destruction of a city when employed in sufficient quantity. "Saturation" bombing by hundreds of aircraft using both high explosive and incendiary bombs in som cases generated fire storms on the surface that, in a single raid substantially destroyed the target city (Hamburg, Tokyo). Althou the development of radar-guided anti-aircraft artillery and all-weather interceptor aircraft greatly increased defensive capabili the attrition thus imposed on the great bomber fleets turned out be prohibitive only in the case of daylight bombing--which was no required for the saturation bombing of cities.

When the first atomic weapon destroyed Hiroshima, the military offense took a great leap forward of the defense. The vastly increased destructive power of a single atomic weapon, in this case some 2,000 times as great as a heavy bomber load of tha time, rendered attrition air defense futile. Even if such air de enses could achieve 90% effectiveness--a fantastically high figur never remotely approached--a single ten-bomber raid would be like to destroy an entire city.

At this writing military offensive striking power is muc further advanced relative to active military defense. They hydro bomb, or fusion weapon, can today achieve the destructive power 59 megatons of TNT within the weight and volume restrictions of a single heavy bomber, or, soon, an intercontinental ballistic miss

payload. Such a bomb is approximately 2500 times as powerful as those that destroyed most of the cities of Hiroshima and Nagasaki only 16 years before. And larger-yield bombs are already technically feasible and may be manufactured in the next few years. There is currenlty no operational active or passive defense against these weapons when delivered by ballistic missile. The active air defenses against manned bomber aircraft employ the latest radar and missile systems, but are very much less than 90% effective.

Although the United States and the Soviet Union are both developing active anti-ballistic missile defense systems, such systems are unlikely to overtake the threat to the extent of providing effective city defense. The currend (and first) generation of such systems, such as NIKE ZEUS, have only a limited capability to deal effectively with rather simple nosecone penetration aids such as decoy balloons and darts. Even if they could deal with these devices, the ZEUS development program is lagging the ICBM programs by over five years, so that while there are already operational intermediate range and intercontinental ballistic missiles, an operational city defense consisting of NIKE ZEUS could only be deployed to protect the nation's fifty major cities in the latter part of the decade. It would be absurdly optimistic to believe that the offense will refrain from developing additional countermeasures to the defense in the course of those five or more years. In fact, there are already reports in the technical press of second-generation, advanced electronic countermeasure systems to

further aid the penetration of local defenses by missile warheads.

The development of very large yield warheads of 100 megat and more renders most known forms of decoy discrimination and defensive counter-countermeasures futile, because these all rely on at least some atmospheric "filtering" of the swarm of threatening objects consisting of nosecone and decoys, and such large warheads can set entire urban areas on fire by their thermal effects even i detonated above the atmosphere. Even the Ballistic Missile Early Warning System (BMEWS) and the Missile Defense Alarm Satellites (MIDAS) would fail to provide warning against orbiting satellites carrying such large weapons that they could destroy metropolitan areas without re-entering the atmosphere from their orbits, being triggered nearly instantaneously by radio signal.

The above discussion only summarizes the results of many studies concerning the technical feasibility of population defens against nuclear-armed ballistic missiles. These gloomy conclusio are intended to show that cities as we know them cannot effectivel be defended from attack for the foreseeable future by active syst but it is not intended to argue against the development of active ballistic missile defense systems. Such systems may have substan strategic value in spite of their lack of effectiveness in defend populations. They may introduce considerable uncertainty into en caluclations concerning the effects of his launching a massive su attack, because the enemy may require well over 90% success in de ing our retaliatory force bases to reduce retaliation to an accep

level, while active anti-missile defenses may at least make possible something less than this. Such defenses may also be considrably more effective in the preservation of "hardened" or passively sheltered military installations than they are in protecting the much more vulnerable cities. Such defense could also achieve a substantial degree of effectiveness in defending even cities against low-grade threats of nuclear blackmail from nations having only very primitive nuclear-armed ballistic missiles. Nevertheless, whatever its possible strategic value, active anti-ballistic missile defenses cannot be expected to effectively defend cities from ballistic missile attack. For primarily this reason, bith the United States and, later, the Soviet Unio have developed a strategy of deterrence to replace the impossible defense.

Deterrence is fundamentally a form of psychological defense. Its essence is the threat of retaliation. If a nation has the capabil and commitment to retaliate against an attack to an extent unacceptabl to the potential attacker, this capability and commitment are sufficie so as to be credible to the potential attacker, then a rational attack may be deterred from attacking because his subsequent losses would out weigh any possible gains. Unfortunately, the doctrine of defense by deterrence is subject to grave uncertainties. The enemy may not be rational. He may be misinformed, or see things rationally but very differently from what we calculate. There may be accidents and false alarms that, together with a reciprocal fear of surprise attack, cause one or both sides to "pre-empt" in an attempt to get in the first blow

and thus reduce the power of the anticipated enemy attack. (This facetiously called "Retaliating before you are hit" or, "going second, first!") Countries other than the United States or the Soviet Union may launch weapons at one or both superpowers from mobile locations such as submarines, ships, or aircraft whose identity cannot be traced, in order to start a war between the two out of either ambition or desperation in some crisis. The current attention being given arms controls is a specific effort to protect the stability of what Wohlstetter has called "the deli cate balance of terror" against such uncertainties and accidents. Unfortunately, the diffusion of nuclear weapon technology goes un checked by an inspected and enforced world test and development ban, so that in a few years these uncertainties will have been multiplied by the addition of several more nuclear powers.

The poverty of technologically-oriented attempts to insure the survival of cities may be even more dramatically illustrated by the impending threat of even less detectable and "stopable" delivery vehicles for nuclear weapons: shipping and suitcases. Nuclear fission weapons of the destructive yields of the Hiroshima and Nagasaki bombs (20 kilotons of TNT) can already be packaged sufficiently compactly so as to fit inside suitcases and shipping crates. Such "time bombs" need not even be personal planted--they could be mailed to the target cities. It would not be practical to inspect all shipping for such weapons without maj economic disruption.

From the above discussion, it should be clear that the revolution in military technology, specifically in the destructiveness and speed of delivery of weapons, has threatened the destruction of urban concentrations far beyond the extent to which it has augmented active defensive capabilities. Furthermore, offensive and defensive military capabilities are very likely to continue their sharp divergence, particularly with the impending breakdown of such psychological defenses as deterrent strategy due to the diffusion of nuclear weapon capability.

RELATIONSHIPS BETWEEN ACTIVE AND PASSIVE DEFENSES OF URBAN AREAS

Fallout shelters reduce the area required to be defended from nuclear bursts from a continental to a local one. In the absence of even fallout shelters, active defenses would have to be good enough to prevent numbers of nuclear warheads from bursting anywhere in the continental United States. With the widespread employment of fallout shelters, active defense coverage may be concentrated over target areas only, reducing the area covered by at least an order of magnitude. If blast shelters are provided in targ areas, the local defense requirements are further relaxed by permitti much lower altitude atomic intercepts and horizontal defense zones covering only builtup areas, since near misses might be tolerated without undue casualties. Thus active and passive defense are compl mentary, and the increased effectiveness of one relaxes the require for the other.

Passive defense by urban dispersal has very different effe in interacting with active anti-missile missile defense. By distri- buting the population over a larger area without reducing its vulne bility to blast, it increases the local defended area requirements for active defenses. Ideally, from the point of view of an effecti active defense system, the population would be concentrated into ve dense small islands, over which massive defensive firepower could b effectively concentrated. Unfortunately, there is not likely to be effective active defense, because the larger yield (over 50 Megaton

weapons may be detonated above the major part of the atmosphere and still set a city on fire, and the active defenses must rely on atmospheric sorting of decoy warheads to effectively concentrate their fire. To put it another way, effective active defense requires sorting out of "false" warheads or decoys. The only way this can be done by observing the different physical behavior of the lighter decoys from the nosecone carrying the warhead, when they enter the atmosphere. But the larger warheads need not re-enter to destroy cities, hence no decoy sorting (radar can be easily fooled), hence no effective defen

The reason this essay recommends dispersal rather than blast shelters, in spite of the fact that the latter is more efficient when used with active defense, is that there is no effective active defen On balance, relying on the purely passive defense of dispersal seems best.

THE FUTILITY OF "DOWNTOWN" SHELTERS ALONE

The current United States civil defense program calls fo the identification of basements and interior areas in downtown or core areas that would be suitable as fallout shelters, and their stockage with minimum food and water and medical rations. While this program may be worthwhile in itself in the event of certain kinds of attack, it will be useless in others. It should be made quite clear that this program will be of use in only very limited tack contingencies, and perhaps not even the most likely ones.

First of all, this program will only protect the people in these shelters from fallout, not from blast. Thus direct hits near misses against cities would vitiate their utility. Second, most of the population in and around cities will not be within wa time of the subject large building shelters unless the attack tak place during working hours. Finally, even if the attack does tak place during working hours, mostly males and unmarried women or t beyond childbearing age will be sheltered. The women of childbea age and the children will be in chiefly suburban homes, and will be sheltered by this type of fallout shelter program. Furthermor the people who are fortunate enough to be in the core areas durin a non-city attack will undoubtedly wish to, and mostly insist on, leaving their shelters before the two week strong radiation peric over, in order to be with their families, or to bring their famil to the shelters. In summary, the following conditions must be m

the current program to have any utility beyond publicity of the problem:

1. Attack during working hours
2. Attack during working days
3. Attack <u>not</u> against cities
4. Attack follows adequate warning time.

The first two conditions would appear rather unlikely, except possibly in the case of a pre-emptive attack forced on the Soviets by United States actions. The third condition justifies city fallout shelter programs, which do nothing to save the population if this condition is not met. The fourth condition can probably be achieved.

4. MILITARY STRATEGY CAN THREATEN THE CITY

The previous discussion argued that cities as now constituted are indefensible by any foreseeable military technology against current and developmental offensive bombardment systems. One may respond, "Very well, cities cannot be defended. But why should anyone wish to attack them?"

The fact that cities are targets of military attack is a fairly recent historical development--unless one goes back to the fortified cities of medieval times. Certainly in the elegant limited wars of the seventeenth and eighteenth centuries, cities were not targets, and even in the nineteenth century attacks on cities as such were relatively rare. In World War II cities became targets for primarily two reasons: First, cities were bombe by Franco (Barcelona) and Hitler (Coventry, London, etc.) as a terror weapon intended to break the will of the people to resist. Second, city bombing was employed by the Allies ostensibly to red the industrial output of their associated industries and the work who lived in them. Neither of these objectives was entirely succ achieved by the destruction of cities, but the bombing was carrie nevertheless. In any future central nuclear war, the reasons why cities may be targets will perhaps include these, but will possib be somewhat different.

Estimates vary widely as to the probable duration of cen nuclear war. The United States, and in particular the U. S. Air has tended to be preoccupied until recently with what has been ca the "spasm" war, in which most strategic weapons were launched as quickly as possible in the hope that they might still catch some

of the opposing forces on the ground. This unstable posture wa chiefly the result of the great vulnerability of bomber aircraf on the ground and unprotected missile sites to surprise bomber missile attack. Even at this time, however, the U. S. Navy, to lesser extent the U. S. Army, and, significantly, the Soviet Un tended toward the view that even central nuclear war might pers months or even years, perhaps in "broken-backed" strength, foll an initial massive exchange of strategic weapons.

With changes in weapon technology came changes in the estimates of the length of central nuclear war. As mobility an concealment was used to reduce the vulnerability of strategic deterrents such as the missile-firing Polaris submarines, and dispersal and "hardening" was used to reduce the vulnerability fixed land-based systems such as Atlas and Minuteman ICBM, the tactical advantage of "going first" or pre-emptive strike was to a point where firepower advantage could well devolve on the slowly responding combatant. This, together with much increase concern and understanding of the dangers of accidental initiat and command and control capabilities for deliberate and select strategic responses has further tended to expand estimates of t length of central nuclear war.

Let us assume that enemy military planners (and our o have the gross alternatives of "targeting" (considering for bo ment) three different classes of target systems: Strategic an tactical military targets alone (called counterforce targets); industrial areas alone (called countervalue targets); or a mix

of the two (called mixed counterforce-countervalue targets). If only a very short war is to be expected, we might expect most of the weapons to be targeted against the opposing weapons, or on w are called counterforce targets. This is to reduce the number o such weapons that are used against us as quickly as possible, wh some of them are still vulnerable on the ground. It is a kind o offensive defense. To hold back one's own vulnerable missiles o the war starts is to invite their destruction on the ground, and besides that the war is too short to make disruption of industry significant objective. Nevertheless, a relatively weak power mi even in these circumstances use his missiles mostly or entirely for countervalue targets (or threaten to, and to make the threat most credible, irrevocably plan to do so), hoping thereby to achieve deterrence by nuclear blackmail since destruction of the threatening force would not be possible. Although this latter p bility is not likely to arise until the substantial further diffusion of nuclear weapons, it is a problem that the Soviet Un must face with France and England even now. If the United State achieves a sufficiently great missile superiority over the Soviet Union so that the latter can have no hope of blunting a U. S. co force strike, the Soviet Union may also elect a countervalue tar strategy in order to preserve deterrence of a U. S. first strike

The increasingly likely situation, however, is one in which both the United States and the Soviet Union possess substa

and roughly comparable missile forces of a relatively invulnerable nature, so that counterforce strikes become a form of unilateral disarmament. If strategic forces become increasingly less lucrativ targets, the alternative targets are tactical forces and urban-indu trial areas. Tactical forces, due to their mobility and dispersion capability, may make relatively poor targets compared to cities. This leaves cities. Where previously the targeting strategy would possibly conciously attempt to avoid damage to cities to "spare the hostages" and thus preserve bargaining power for the protection of one's own population, the approaching relative invulnerability of military targets and the proximity of purely industrial targets to urban areas may suggest the destruction of at least a few hostage cities as a means of military bargaining.

In addition to the above strategic threat to cities, there is also the strong possibility of an inadvertent, or unintend but unavoidable threat resulting from what is intended to be a coun force attack. The increased dispersion of military forces (for red vulnerability), together with the increased lethal area of strategi weapons, and the requirements for such larger yield weapons resulti from advances in active and passive defense of military installatio may make it impossible to strike at strategic military targets with simultaneously imposing grave damage on urban-industrial areas. Fi storms can be ignited by 100 megaton bombs over 100 miles from thei burst points, and most military installations have one or more urba industrial areas within this radius. Furthermore, not all intercon

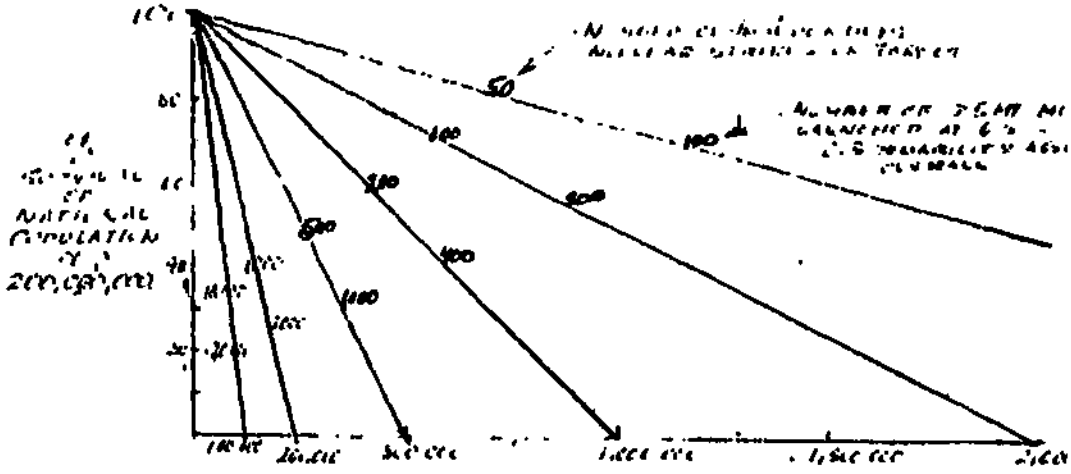
ballistic missiles will be accurate, and in an exchange of hundre
dozens may fall within lethal radius of urban industrial areas.
Finally, there does not appear to be any prompt and practical wa
counterforce targets such as navy yards can be dissociated from
cities.

5. ARMS CONTROL INTERACTIONS

The minimum size of a community still presenting a lucrative atomic target depends as much on the number of available missiles the enemy(s) has for striking them, and the total number of such targets, as it does on the individual qualities of the target itself. This greatly complicates the problem, because neither the number of missiles nor the number of urban targets is likely to remain constant or stable unless artificial constraints are imposed. Such constraints might include arms control and/or partial disarmament agreements. If arms control can stabilize strategic retaliatory bombardment forces at, say, 1000 intercontinental ballistic missiles on each side, then there would have to be at least 2000 separate communities in the United States to insure survival of 50% of the population against an all-out counter-value (counter-population and industry) attack....provided fallout shelters are available to all, target areas are distributed so as not to overlap, and missiles are assumed to be completely reliable and effectively accurate and capable of penetrating any local defenses. These last qualifying assumptions are either plausible in themselves, or made for the sake of simplified illustration. Missile unreliability and inaccuracy will merely reduce the number of targets required or, alternatively, increase the missile inventory required for a fixed percentage of destroyed targets.

Assuming that we make our calculation for a time in which the United States population will be some 200 millions, the minimum size of a community still presenting a lucrative target is 200 millions X 50% divided by 2000 missiles, or 100,000 inhabitants. This assumes uniform

distributions and absence of consideration of such factors as local specialization. If the number of strategic effective missiles on ea sides can be reduced to 100 by improvements in the accuracy of arms control agreement inspection of inventories, we then have 200 millio divided by 100 or 1,000,000 inhabitants per city for 50% national su vival. Correspondingly, a maximum city size of 500,000, given the s number of 100 missiles, would assure 75% survival, 200,000 for 90% s vival, or 100,000 for 95% survival. Figure 1 illustrates this relat ship. The effect of nonuniformities in community size, provided the maximum size limit is observed, will tend to increase the number of gets and hence the percentage of the national population surviving a attack.



NATIONAL POPULATION SURVIVAL AS A FUNCTION OF TARGET COMMUNITY SIZE

FIGURE 1

6. ALTERNATIVE PROSPECTS

The alternative prospects for urban survival operate on thr levels of scope and detail. The first level of greatest scope and l detail is that of geopolitics. Here the variables of military, econ and political strategy are aggregated to determine the form of globa interactions among national and international organizations. It is this level that the major choices between political reorganization f peace or technological reorganization for war must be made. Either is eliminated or most rigidly and reliably controlled by political f that do not now effectively function, or in order to usefully surviv otherwise recurrent nuclear wars, it may be necessary to radically c the technology of our civilization's production, consumption, and ro activity. These are the extremes of a spectrum of possibilities; it certainly possible, and much more plausible, to continue in the diff quest for international order, while at the same time taking certain technological precautions that will reduce the level of damage resul from general war.

The second level of aggregation is that concerned with the socio-economic forms within a nation--essentially the problem of nat design. Here we are concerned with the size, number, and distributic of urban-industrial concentrations, questions of regional specializat and autonomy and interaction, and the long-term social and political we wish to see promulgated among our population. These large-scale n considerations will be constrained by the international strategic co tions resulting from geopolitical prospects for peace, limited wars,

general and total wars. With the determination of these national forms, desirable design criteria for local metropolitan areas can be formulated.

Finally, at the level of least still workably significant scope and greatest possible detail are the alternatives for urban-industrial or metropolitan patterns of physical, political, economic, social, and cultural development. Here we must deal with questions of the size and topology of cities, structural density, tax resource distribution, transport accessibility, variety of vocational and avocational choices, political and social participation, cultural richness, etc.

ALTERNATIVE PROSPECTS ON THREE LEVELS OF ANALYSIS FOR THE INTERACTION OF MILITARY TECHNOLOGY AND METROPOLITAN GROWTH AND FORM

	UNITS/ ACTORS	MAJOR VARIABLES	INTERACTION DYNAMICS
1. GEOPOLITICAL LEVEL			
peace & international order or limited wars & limited intl. order or limited & general wars - intl. anarchy	blocs nations	security trade bal. communications rate & level of technology	trade aid trade war propaganda war limited war general war international organization(s
2. NATIONAL-REGIONAL LEVEL			
integrated economy on national level integrated economy on regional level locally integrated economies loosely linked degrees of centralization of control (federal-local) (public-private) degrees of centralization of planning (federal-local) (public-private)	national regions or districts	population natural resources cultural resources national traditions industry & commerce defense policy	politics-legis business, indu rese education social operati cultural opera military force and operations space-economy regions functional ec of regions

ALTERNATIVE PROSPECTS ON THREE LEVELS OF ANALYSIS FOR THE INTERACTION OF MILITARY TECHNOLOGY AND METROPOLITAN GROWTH AND FORM

(continued)

	UNITS/ ACTORS	MAJOR VARIABLES	INTERACTION DYNAMICS
3. LOCAL METROPOLITAN LEVEL			
current core+suburbs	cities	variety	personal decisions
core only (Moscow?)	metro-politan districts	directed & spontaneous communica-tion	political particip
core + satellites	towns		growth
galaxy (Stockholm)	villages	comfort	adaption & change
dispersedanarchy (IA)		costs	redistribution
star (Copenhagen, Boston?)		flexibility	redevelopment
ring (San Francisco, Boston?)		accessibility	esthetic response
chain		structural density	industrial activit
uniformly dispersed (mechanized rural)		circulation capacity	commercial activit
underground		specializa-tion	entertainment
mobile (floating?)			education
			law & crime

On the geopolitical level, the prospects are not encouragin We would like to say that governments will henceforth be not only ra but also possessed of correct information and be unperturbed by unce tainty. This is not likely to be the case. No world government cap of developing and enforcing international order is likely to arise f at least the next generation, and perhaps not even then or until aft decimating thermonuclear war. At best, the prospects are for protra conflice between East and West (and also occasionally among the unco on an economic and limited military basis--limited military conflict strained by unilateral and tacit and possibly even a few explicit ar controls. Partial disarmament is ineffective, but may be attempted. General and complete disarmament will not remove the danger of gener war, but only give it a prolonged, different, (and hopefully less li chain of causes. Although wars may be limited, they will not necess be limited to local, tactical engagements. Limited strategic retali may be employed where one side feels itself strained tactically, and means possible bombardment of "homeland" targets such as cities--wit without warning sufficient for evacuation. (See "The Strategy of Li Retaliation: Some Constraints," by Clark C. Abt and Ithiel de Sola in LIMITED STRATEGIC WAR, edited by Knorr & Read, Princeton, 1962.)

The conclusion we must unhappily draw from geopolitical con siderations is that there will continue to be a significant military threat to urban survival for the forseeable future. This is not to that the demise of the Western world is at hand, but only that an u number of cities will be threatened with nuclear attack for the fore future. The outlook is bleak, but not hopeless. Survival is proble

but possible with effort. The specific problem, in terms of urban organization, is how to provide maximum survivability of limited nuclear bombardment within economically feasible expenditures that, ideally, achieve civic improvements quite independent of survivability. To put it another way, what form of insurance can be bought for our cities that will yield peacetime dividends in increased urban effectiveness, and thus pay for themselves even if we are fortunate enough to avoid war.

Given the probable geopolitical threat of protracted and hopefully limited conflict, what are the alternatives on the national or regional level in response? There are several predominant demographic trends that must be taken into account. First, some three-quarters of the population of the United States now live in cities or their suburbs, and the proportion is likely to increase to 90% within the next few decades. Second, most of the population is found within some 100 miles of the coastline--a fact that bodes poorly for effective defense in depth against even manned bomber attack. Third, nearly half of the nation's population is settled in the northeast quadrant of its geography, which is also the area that is likely to receive the most cumulative radioactive fallout from either a counterforce or a countervalue attack.

Perhaps even more important that these demographic factors are the questions of public opinion and its interactions with government poli In late 1961, there was a major shift in the administration's proposals for civil defense, although no new technical facts had been brought to light. One can only conclude that the shift in emphasis from private to public fallout shelters was the result of political factors. Although these political factors might include strategic considerations of Soviet

policy and possible shifts in targeting, a major cause may have been the unfavorable (both directly and indirectly in the form of counter productive activities) public response. In this case, it was probab the combination of external political requirements (the Berlin crisi forcing the President to suggest civil defense measures that could b interpreted to immediately stiffen the nation's will to resist threa together with the unfortunately discriminatory, economically selecti nature of a private fallout shelter program, that elicited the wides public discussion and, gradually, dissatisfaction.

The question of what kind of survival policy should be ad- vocated and executed by the government must be answered in a comple context of national resources, traditions and public attitudes, and technical factors of defense technology and military planning facto Whether or not to build shelters, the location of such shelters loc their national distribution, what kind or kinds of shelters should built, who should build them, who should pay for them, etc. are all that interact with the current nature and future possible forms of nation's metropolitan areas. These factors will all be affected by more definable (if yet uncertain) military variables of nature and of bombs that the enemy might use in an attack, burst altitude, del speed and accuracy, available warning, likely number of false alarm long-term alert periods, the alternate target systems, winds, weath time of year, duration of attack, etc.

We have already discussed the possibility of enemy resort counter-city attack as a means of military bargaining in the coming

in which counterforce attack may be rendered futile by the great reduction of force mobility through hardening, dispersal, mobility, and concealment. This era is not yet here, however, and may not be completely dominant for almost another decade. In this forthcoming decade, rational strategic considerations suggest the primacy of strategic and tactical military forces as target objectives. For an enemy to destroy our cities would remove most of the restraint we might have had to prevent our own forces from attacking his cities, in the expectation that ours would therefore be spared. Unfortunately, military operations are not always carried out according to the dictates of strict rationality. Command and control may break down. Communications may be distorted. Accidents and miscalculations will occur. Thus there is some threat to cities even before they become the only economically attackable target by reason of vastly reduced strategic force vulnerability. This leaves us in a situation where the most likely threat to cities for the next few years will be the radioactive fallout generated by a nearly pure counterforce attack, with an additional less likely but far from trivial threat of direct bombardment of some cities either as a result of accident, as part of a demonstration of "firmness," as in limited retaliation, or because they are inseparable from military targets (ports).

In the awareness of this general distribution of threats to our cities, the Administration has elected to follow a policy of simultaneous working on the geopolitical level for general and complete disarmament or at least arms control, and on the national level it is executing a a federally-financed and administered public fallout shelter and educational program, augmented by the less-than-favorably received and antecedent private shelter program. The working assumption of this program (most unfortunate

rarely made clear by officials and never by the President) is that t
likely kind of attack in the next few years will be counterforce wit
ground bursts, thereby generating an almost entirely fallout threat
most of the nation's population in cities. (Fallout shelters will,
course, not save those persons in the immediate area of military tar
subject to direct bombardment, due to the thermal and blast effects.
this should be the case, then according to the Rand Corporation anal
performed by Herman Kahn, ten to one hundred million persons would b
saved by an extensive (Ten (10) billion dollars) fallout shelter pro
depending on the weight of the attack. Even if the attack should be
directed half at cities and half at military targets, forty to one h
million persons might be saved by the fallout shelters. In short, t
fallout shelter program is believed to provide the highest payoff in
against the most likely kind of attack. It is for these reasons tha
arguments of uninformed persons against fallout shelters on the basi
their failing to provide protection against blast and firestorms are
relevant. They complain that the fallout shelter program fails to a
something it was never meant to do--to protect the cities from direc

On the local or metropolitan level, the alternatives posed
the above discussed policy are twofold in time sequence. In the nea
the question is chiefly one of maximizing the number of persons that
have public or private fallout shelters accessible to them within th
timated available warning time. There is little to suggest that tha
lem justifies any sort of substantial reorganization of metropolitan
either politically or physically. In the not much more distant futu

however, (and, it might be noted, one in which metropolitan planning might have some practical effect on the physical form of cities), the increasing threat of direct bombardment of cities will require serious consideration of unprecedented political and/or technological modifications. We are not in this essay concerned with the forms of international order as such, except to consider that the chances for an effective geopolitical solution removing the threat of thermonuclear bombardment appear remote. Since we are concerned directly with the question of the safety of cities, we will concentrate on the possible modifications that might be made to promote survival in the face of this threat.

When we thoroughly examine the possibilities for city survival of intentional direct attack with weapons ranging up to 100 megatons in yield, we find thaey are few and expensive indeed. A moderate degree of dispersal, by itself, is futile against the 25-mile heavy damage blast radius and the 60-mile heavy firestorm radius. Fallout shelters, while perhaps having served a usefulfunction in the time of lesser yields and more likely counterforce attacks, will then only serve to protect the inhabitants of those cities that are accidentally or intentionally s spared, since they do not by themselves provide protection against fire or blast to significant extent. Active defenses may slightly reduce the lethality of the large weapons, at very great cost of billions, by forcing detonation at higher than optimal altitude of some 40,000 feet, or by providing a marginal capability for intercept at optimal burst altitudes or slightly above. It may generally be concluded that their most efficient function will be to provide a contribution to the defense of very

"hard" command centers and strategic bases, which in spite of their "hardening" would otherwise be vulnerable to 100-megaton surface bur Such protected installations could sustain the heat and blast from h bursts skirting effective active defense capability, but cities as p sently constituted could not.

Very widespread and more uniform dispersal is also not a sa factory answer, since it essentially eliminates the amenities of the urban form as we know it, without providing a clear payoff in terms substantially increased survival vs. pattern bombing.

The question is, can the political, social, economic, and cultural forms of the metropolis be preserved by <u>any</u> modifications in the face of an onslought by 100-megaton bombs? If such weapons a directed only or primarily at military bases separated in space from cities, the answer is a definite yes, but there is no strong <u>militar</u> justification for the modification of urban patterns. If the weapon directed at cities themselves, the answer must be an extremely quali weak, and uncertain yes. In fact, the "yes" is so weak as to consti a "no" for many people. What would be required to survive this kind attack and its blast, thermal, and radioactive effects would be a co tion of dispersal and hardening--precisely the measures that are alr being taken by military organizations in an attempt to protect base direct attack. If such measures could be taken, then active defense cities might once again pay off, for the reasons given previously.

What might be the form of "hardening" and dispersal in a me politan context, that would still preserve a significant portion of politan values? And why are such measures believed to provide a de

of survivability? If cities were "hardened" only--that is, provided with blast shelters--the fire storms above their shelters would probably nevertheless suffocate them with smoke or remove the available oxygen. This is what happened in Hamburg after the fire raids. Even completely independent stores of compressed air or oxygen would not suffice, unless the blast shelters were impractically deep, due to the heat from the fire storms above ground. There were some shelters in Hamburg that were opened two days after the great fire raid and found to still have air temperatures of 1500° F.

On the other hand, if urban dispersal is employed without benefit of blast shelters, the large blast radii of the 100 megaton weapons, and the much larger thermal overload radii, would nevertheless cause severe damage and a high proportion of deaths and casualties. The combination of dispersal together with blast shelters would somewhat reduce the probability of massive fire storms of such intensity that very deep autonomous shelters would be required, while at the same time providing the minimum fire and blast protection required by local conditions. The buildings in a "garden city" might be knocked flat, and some of them might catch fire, but the people in shelters adjacent or even underneath would not be threatened by the tremendous temperatures and oxygen starvation resulting from fires in much more densely spaced surroundings.

The specific forms of "hardening" and urban dispersal may be varied bothto conform with local conditions ideally, and perhaps as a result of further research. Concrete basement shelters in fireproof apartment houses, schools, office buildings, and factories, that are used conventionally for food and tool storage useful for survival appear

an obvious and relatively low opportunity cost possibility for harden
For private homes, concrete storage rooms adjacent to basements but n
directly under houses might be effective. There are many possibiliti
but since we are concerned here with changes imposed on urban forms b
military technology, rather than the changes in building construction
we will concentrate on the alternatives for metropolitan dispersal.

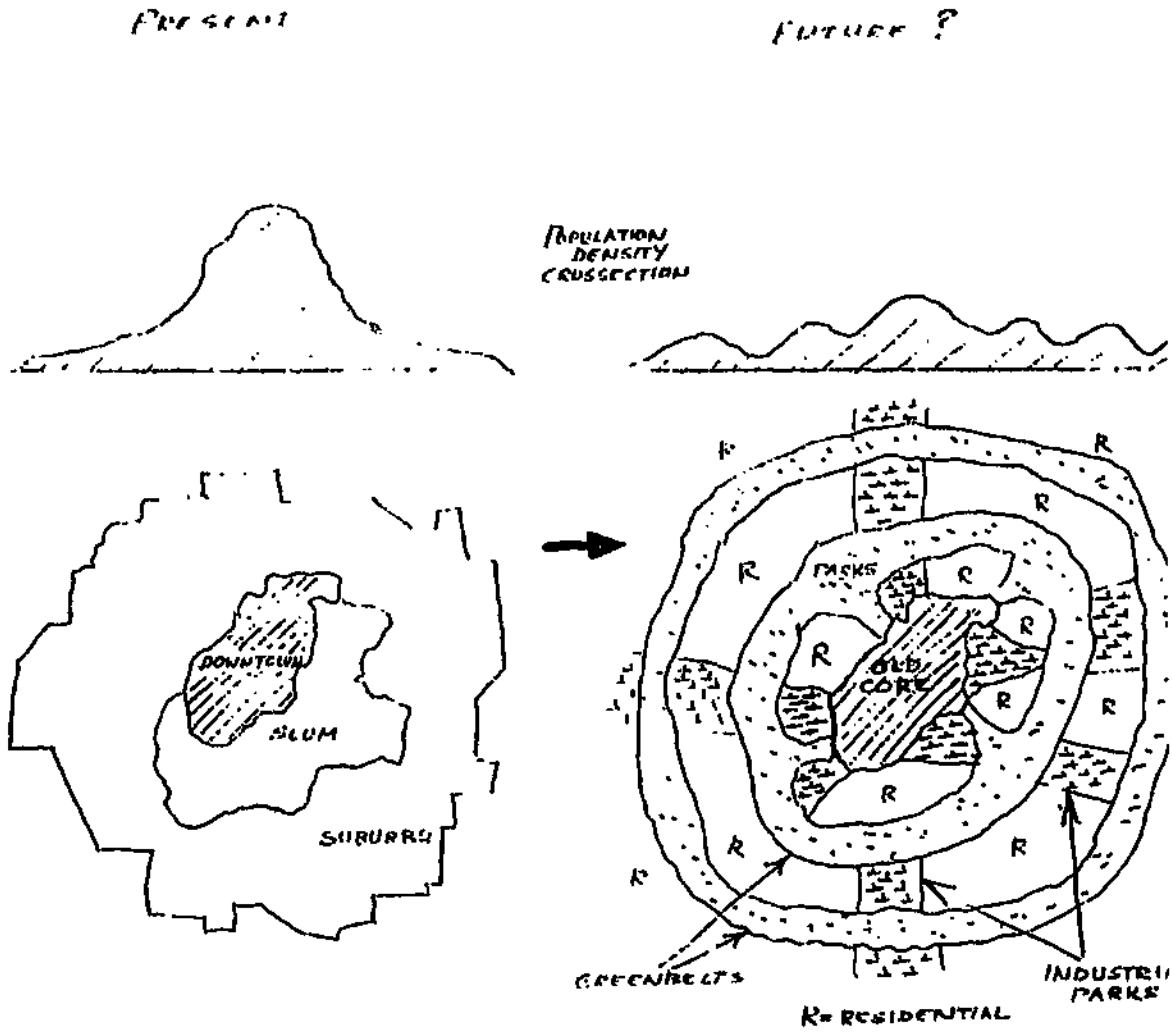
Dispersal of current urban population concentrations can tak
the form of multiple dense cores, cores with satellites or galaxies,
persed sheets, stars, rings, or chains. (See following chart for a t
lated comparison of potential pattern characteristics.) The actual c
that may be made may result from the particular concatenation of loca
conditions of transport routes, topography, city design, and industri
demand. Combinations of one or more of the alternate patterns of dis
are quite likely: For example, core-galaxies, star-rings, and disper
sheet-chains. Much more quantitative systems analysis must be perfor
to determine the relative cost-benefits of the various patterns in th
economic, industrial, social, esthetic, and military survivability el
The following chart attempts to suggest only quite curedely some of
the more obvious relative advantages and disadvantages.

ALTERNATIVE URBAN PATTERNS

TYPE:	1 CORE	2 DISPERSED SHEET	3 GALAXY	4 STAR	5 RINGS	6 CHAIN	7 CURR COMBIN	numbe refer other colum
CLOSEST EXAMPLE:	Moscow	Los Angeles	Stock-holm	Boston	San Fran-cisco	Minnea-polis & St. Paul	Chic	
MILITARY ADVANTAGES:	easiest active defense	almost none	best for harden-ing & anti-fire	fair active defense	good anti-fire	difficult target		2
MILITARY DISADVANTAGES:	easy target, fire storms	easy target, diffi-cult defense	vuln. to area weapons	some danger, fire storms	expen-sive defense	expen-sive defense		1, 2
CIVIC ADVANTAGES:	much variety, good distrib. & polit. identity	flexible evenly distrib. load	good comm., polit. indep. spont. commun.	efficient production rapid com-mun., pre-serves old center	good comm., low density visual space	isolated industry flexible		1,
CIVIC DISADVANTAGES:	rigid, congested regiment. to control	high cost, long dist., low cul-tur. & polit. identif.	fixed local bound., long dist.	congested core limited growth	low adapt.	long time distances		1,
GROWTH CAPAB.:	fair	good	fair	good	poor	poor		1
FLEXIBILITY:	poor	good	fair	fair	fair	good		3
ACCESSIBILITY:	good	poor	fair	good	fair	poor		2
CIRCULATION: CAPACITY	fair	poor	fair	good	good	fair		1
LOCATION OF FIXED ACTIVITIES:	central	random	multi-centered	linear	linear	multi-centered		1
FOCAL ORGANIZ.:	high	low	moderate	high	moderate	low		1
GRAIN:	sharp	blurred	sharp	sharp	sharp	blurred		1,

ALTERNATIVE URBAN PATTERNS (continued)

TYPE:	1 CORE	2 DISPERSED SHEET	3 GALAXY	4 STAR	5 RINGS	6 CHAIN
STRUCTURAL DENSITY:	high	low	high & low	high & low	high & low	high
SPECIALIZATION:	low	low	high	fair	fair	high
LOCAL VARIETY:	high	high	fair	fair	fair	low
ESTHETIC CONTRAST:	high	low	fair	high	fair	fair
POLITICAL BURDEN:	high	low	high	moderate	high	moderat
COST/ECONOMIC RELOCATION:	moderate	moderate	moderate	moderate	high	high
"INEVITABILITY":	high	high	fair	fair	low	fair
POLITICAL ANALOG:	Socialist Democracy	Anarchy	Federal Democracy	Monarchy	Aristocracy	
ESTHETIC IMAGE:	high	worst	moderate	high	moderate	low
NORMATIVE PRIORITY:	3	4	2	1	2	2



Population Dispersal by Alternate Belt Relocation

FIGURE 2

The table on the preceeding page does not offer the alternati of underground cities, although each of the two-dimensional forms spec fied could incorporate subterranean structures for housing their popul in times of terror. Underground blast, fire, and fallout shelters are the same thing as underground cities. The former provide temporary, l comfort protection for months at most. Underground cities would possi be self-sustaining for longer periods of time, but would require an e mous allocation of national resources. Whereas some 100,000 people o a square mile in heavily built up urban areas today, underground citi several hundred feet deep could accommodate ten times that number wit relatively generous personal space allowance of 10,000 cubic feet. O course, this space allowance is generous only as dwelling space; if t is no "outside" one can go to, it may come to be perceived as rather ing.

If the compact core type of urban organization is chosen, ve hierarchies of function might eventually run from industry on the sur through wholesale commerce and transport on the next higher level, th retail commerce and amusements on the next, to another level of trans and finally to homes and schools on the uppermost level, since that w be the most esthetically and healthfully desirable. In an undergroun of comparable concentration requiring extensive vertical layering, t sequence downward might be the mirror image of that above the surface, because the deepest locations would now be the healthiest. Intimatio of this sort of potentiality have been suggested by another valuably fying "novel" (quotes because it is not really much as literature, no tended to be) called Level 7, by Mordecai Roshwald (McGraw-Hill, New 1961).

The prospect of new "fortress" cities, this time armored vertically rather than horizontally, does not appeal to the senses or to economic sense. The cry may someday go: "Better red than buried!" Nevertheless, it is worth pointing out that the core and star configurations would best lend themselves to an integrated subterranean city rapidly accessible from the above-ground metropolis.

The political and social implications of underground cities are not appealing. Complete regimentation of living space and functional space would be required, and certainly no private transport would be possible for at least so long as it took to carve out an entire new landscape underground. Because of the relatively complete social integration such an ant hive would require, commercial and industrial free enterprise, even limited as it is today, would be finished. Furthermore, there would of necessity be the most restricted choices of work, society, and living space. All in all, an underground city would probably require a form of government and social organization best described as a communist military dictatorship. This might suggest to the electorate, if such measures were seriously contemplated, that it might be preferable to be red above ground rather than equivalently totalitarian below ground. Of course there may be many who prefer being underground to being governed by foreign reds above ground. There might be a point to this, provided that the underground cities were only very temporary. Yet their very expense would seem to mitigate against only emergency usage, once constructed.

With respect to the social consequences of urban dispersal (combined with some "hardening") that might be required in the not too distant warlike future, the resurgence of small satellite communities

(whether part of a galaxy, or star, or ring, or chain - it doesn't matter) might see a more cheerful increase in personal initiative - politically, economically, socially, culturally. The current urban concentration at the core permits efficient personal inputs. There is a maximum of passive choice, or spontaneous communication. But one's output is constrained by the need to restrict social impingement to tolerable levels of occasional privacy. With dispersal, the inputs of passive choice from spontaneous communication are more limited (althoug still available at increased time-distance cost), but personal output, personal initiative, personal creative choice are increased. The moral might be, Learn in the core, Go out to create more!

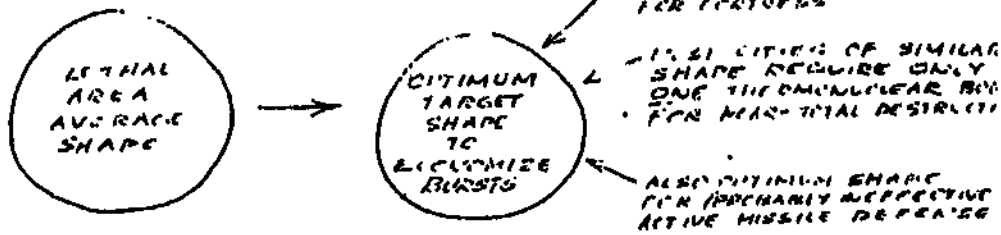
POPULATION RATIO

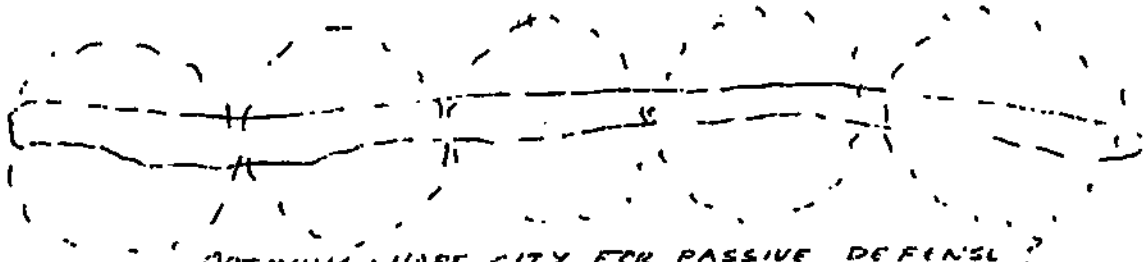
POPULATION IN URBAN AREAS

	Megadeath Rate	Command
U.S.	61.9 %	U.S.S.R. - ?
U.K.	78.2 %	U.S.S.R. - ?
CANADA	61.4 %	[illegible]

INFERENCE: WITH FALLOUT SHELTERS IN BOTH SIDES, U.S. IS ABLE TO BE AS VULNERABLE TO CERTAIN SMALL ATTACK FROM U.S.S.R. (NEGLECTING ECONOMIC RECOVERY)

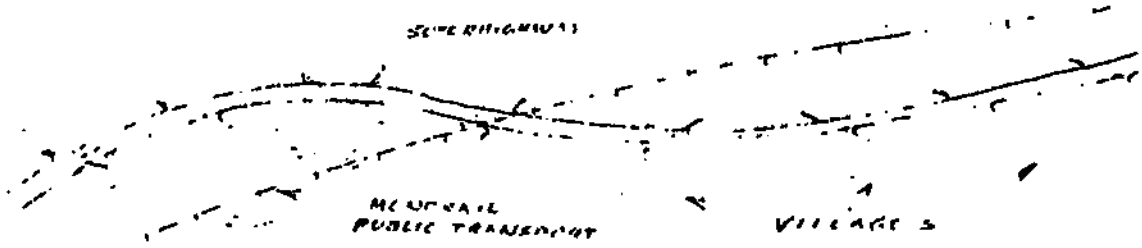
TARGETING TECHNOLOGY

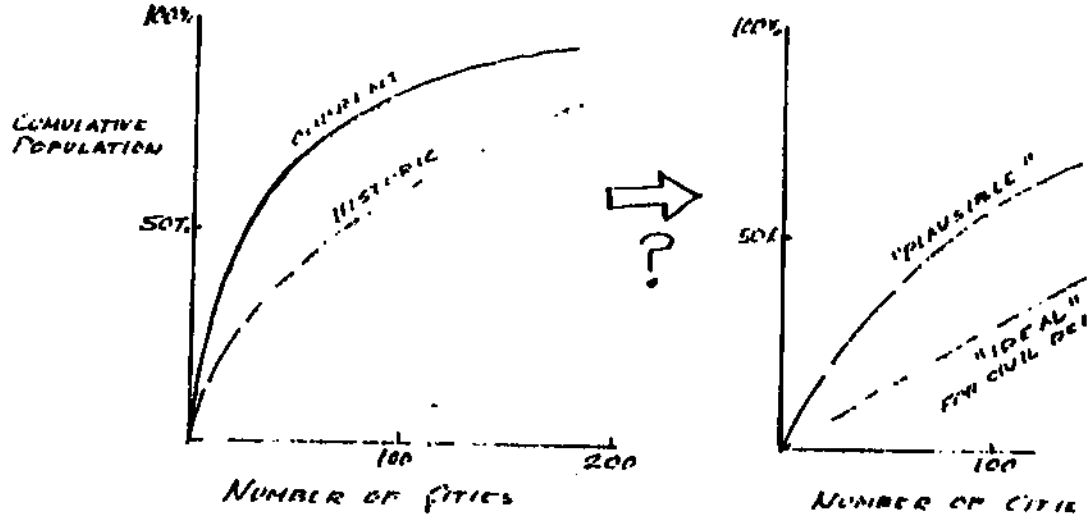


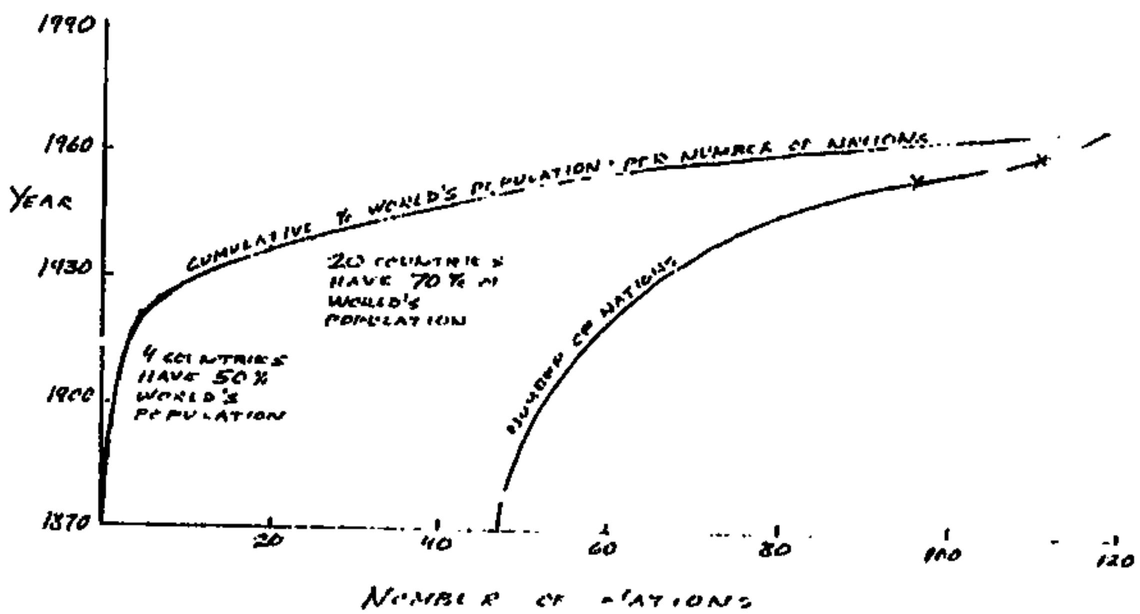


OPTIMUM SHAPE CITY FOR PASSIVE DEFENSE ?
(REQUIRES FEWER BOMBS, REDUCES TARGETING ATTRACTIVE MASS)
- WORST SHAPE FOR ACTIVE DEFENSE !

CIVIC VIABILITY OF OPTIMUM PASSIVE DEFENSE TECHNOLOGY:
- REQUIRES RAPID TRANSPORT.







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ON CONFLICT
20 MARCH 19

7. COST BENEFIT CONSIDERATIONS IN THE COMPARISON OF URBAN DISPERSAL AND BLAST SHELTERS AS MEANS OF SURVIVING THERMONUCLEAR COUNTER-VALUE BOMBARDMENT.

Any discussion of so complex a set of cost benefits must begin with the identification of component cost and benefit elements. These include the major elements of military, economic, political, and cultural costs and benefits - in approximately that ascending order of quantifiabi There are many secondary complicating feedback effects, such as the military significance of all the other elements, the economic significanc of all the other elements, etc. However, let us begin with the considera of the primary component costs and benefits that might be measured, or at least evaluated, in comparing the two strategies for social survival.

Military costs will be naively postulated to consist of fraction of the population killed, this being assumed as a measure of the loss of national productive capacity, will to resist, "value", etc. It is well known that these factors are not linearly related, particularly will to resists and, more important, the will to resist perceived by decision makers. However, since our purpose here is by definition to insure the largest fraction of the nation's population at the least cost, or for a fixed cost, the questions pertaining to ancillary military values may be neglected in this connection. Military benefits are simply the inverse of costs, or the fraction of the population surviving thermonuclear bombardment of populated areas. Enough is known about weapon effects to permit calculation of survival percentages for at least normalized target areas to within perhaps ten percent (not counting the uncertainty introduced by major weapon innovations, such as radical repartitioning of the energy spectrum of thermonuclear weapons, as in the so-called "neutron bomb").

The economic costs of the two alternate approaches may be divided into direct and indirect costs. Direct costs are those incu in the construction or purchase of new equipment entailed by specif aspects of an approach, while indirect costs include secondary effe and opportunity costs.

Economic benefits, again, are both direct and indirect. Direct economic benefits are the professional, skilled, and unskill labor saved from destruction or crippling wounds, and the capital goods and inventories saved from destruction or serious damage, and the economies of scale and/or function achieved by the two alternat strategies. Indirect economic benefits include longer-range improv in the yeild of capital, investment attractiveness, growth rates, a other factors affecting the overall viability of an economic unit.

Political costs and benefits include the relative threat c alienation, the degree of active participation made possible, the efficiency and integrity with which the communities may be politic organized, the relative efficiency with which government can provic community services, etc., together with the relative costs of modif existing arrangements to those required by the alternative approacl

Cultural costs and benefits consist of the reenforcement c degradation of the entire hierarchy of cultural values and their operational correlatives.

The cost benefit comparison below is made between the empl of urban decentralization together with fallout shelters, versus th of continued concentration at current levels with both fallout and blast and fire shelters, as alternative means of surviving thermon counter-population bombardment. It is assumed that the threat will

consist of no more than several hundred (to be limited by arms controls) intercontinental ballistic missiles carrying payloads capable of producing thermonuclear bursts ranging from one to 100 megatons of TNT. If the yield of the weapons is limited to some ten megatons, the results of the cost benefit comparison are altered in degree, but it will be seen that the conclusion of preference is not. Threats of biological and chemical weapons are not here considered, due to either their strategic disutility or the expectation that their development may be limited by arms controls on military research and development. (Biological weapons have too long response times to be efficient as strategic terror weapons, and, like chemical gases, require substantial seeding by numerous aircraft that <u>can</u> be successfully defended against on an attrition basis.

It is assumed that in the event of a major attack on urban population targets with thermonuclear weapons, in the area of total destruction (3 nautical miles radius for a 5-Megaton surface burst) blast shelters as well as fallout shelters would be useless, although the percentage surviving with blast shelters might be slightly higher (40% rather than perhaps 30%). Considering that the downtown area population densities approach tens of thousands per square mile, and that the area of total destruction is some thirty square miles (for 5 MT surface) a substantial number of people might be saved from the initial blast effects by downtown blast shelters. . .perhaps adding up to ten or twenty million people all over the country. What is most questionable, however, is whether these survivers of the initial blasts would survive the subsequent firestorms and very intense local radioactivity. . .and whether or not they could dig themselves out of their

shelters without outside aid (which may be difficult in the face of intense radioactivity and fires). This writer would conclude that, regardless of the type of shelter, the downtown population is unlikely to have a significant fraction of survivers. Thus the additional costs involved in building blast shelters in downtown areas appears unjustified because it achieves no improvement in survival - with one possible exception. The exception is for the cases in which missiles miss their downtown designated ground zero, and detonate several miles away in the suburbs. In this case, the fraction of persons saved by downtown blast shelters might grow substantial due to the additional protection against a near miss. This payoff must be weighed against the probability of such near misses, which promises to be low indeed, because a rather inaccurate missile can still constitute what in terms of lethal radii is a direct hit. ICBM's are designed in their guidance systems to be sufficiently accurate to destroy hardened missile sites if possible, requiring accuracies approaching geodetic uncertainties on the order of half a mile. Anything within two miles of the aiming point may be considered a direct hit on a major large city - hence the unlikelihood of frequent near misses. Complete misses or missile abort are more probable, but against these no type of shelter buys anything, because it isn't needed (except perhaps fallout shelters).

Thus it may be concluded that the main argument between blast plus fallout shelters, and fallout shelters plus dispersal, is not the question of improving survival in the area of total destruction likely to occur at the core of the city. With equal (and insignificant improvement in survival from shelters in this area, the cost benefit comparis strongly favors dispersal plus fallout shelters over blast shelters, because of the much higher local expense of the latter. In the urban

core areas, real estate, even underground real estate, is extremely costly. So is the massive construction activity required to burrow under large buildings, subways, and sewage systems. To adequately shelter the population against a direct hit, one would have to build concrete bunkers many hundreds of feet below the surface - comparable in cost and difficulty of construction to skyscrapers of equal height above the surface. To inadequately shelter this core population against direct hits would be nearly as expensive. Without attempting any pseudo accurate estimate of the costs of construction, a plausible rule of thumb and a conservative one might be that the cost would be comparable to the cost of construction of large modern office buildings above ground. This would not include the costs of disrupting normal service functions during the extended (years) period of construction.

It might be argued that the costs of the urban dispersal scheme are also great, because of relocation and rebuilding up the housing and industry that was formerly in the core areas in dispersed suburban areas. This would be an error, because the urban dispersal scheme proposed in this paper does not call for any substantial relocation, but rather for the building of new homes and industries entirely at dispersed sites, permitting natural depreciation of buildings to gradual thin out the high density core areas.

Let us next consider the urban zones of heavy damage to buildings, in which populations with only fallout shelters would suffer some 40% fatalities and an additional 30% casualties. For a five Megaton surface burst, this zone extends from three to five miles from the designated ground zero burst point. In almost all major cities (over 1,000,000 population) this would be a zone of population density close

people in this zone of heavy damage before dispersal, because they would no longer be there - they would have been dispersed to outer suburbs. Thus the difference in benefits in this zone consists of perhaps one third of the population of this zone in its concentrated undispersed state. Since the area consists of some fifty square miles, per city, and since average densities per square mile in this zone may be over 10,000 persons, one-third of 40% times 50 times 10,000+ persons might be saved by blast shelters here, or approaching 100,000 persons per city. Even assuming that half of these initial survivers die from subsequent radiation and other privations, the saving in life from blast shelters in this zone is still substantial. The cost would still be great - probably again as much as the cost of the aboveground construction at the least. That this cost is "worth it" on the basis of any lives saved justify any cost is not correct, because the same funds spent more efficiently elsewhere might have saved even more lives. It is suggested, although undoubtedly difficult to demonstrate, that the cost of blast shelters in this heavy damage zone can be spent more effectively on urban dispersal. The reason for this is that for urban dispersal primarily tax incentives are required, rather than expensive construction and that these would for a fixed sum offer much greater "leverage" on the problem than heavy shelter construction. It might cost 100 million dollars to build a single blast shelter sufficient to house 1,000 families but a million dollars of tax relief for each of 100 major employers might multiply the number of families saved by reason of dispersal of industry to 100,000 (assuming the average number of employees of 1,000).

In the zone of medium to light damage, extending from five to nine miles out from the surface burst point of a 5-megaton bomb, there might be an average of 10% blast fatalities in the absence of blast shel

ters. Here, however, the percentage of population surviving blast is a strong function of warning time. If people can get into the basements of buildings and away from windows, they are unlikely to be hurt by blast damage to screening walls and flying debris. Since warning time will soon be increased from fifteen minutes to about a half-hour by the MIDAS satellite warning system that detects hostile ICBM's shortly after blast-off, there should be enough time to seek shelter of the naturally available kind. The real problems in this zone of light to medium blast damage are fallout and fire.

Fallout would be guarded against in both the case of blast shelters, and by means of fallout sheltered urban dispersal, so this is not a point of comparison. But fire is, and in particular, the probl of fire storms. Fire storms killed more people in cities in World War I than either chemical or atomic explosives. It has been estimated that some 140,000 people lost their lives in the fire storms of Hamburg, compared to some 80,000 at Hiroshima. It was probably the fire storms in Tokyo that created the greatest production losses in Japan. To enable people to survive fire storms, blast shelters must not only be fireproof, but must also possess their own independent air supply for at least a day. The predominant lethal mechanism of the fire storms is its exhaustion of locally available oxygen, so that as many or more persons suffocate as burn to death. Blast shelters possessing autonomou air supplies would be expensive for the population density obtaining in most metropolitan heavy to medium damage zones. Just how much more expe sive than simple blast shelters is difficult to say.

Urban dispersal with fallout shelters can do much to greatly reduce the possibility of fire storms, and perhaps eliminate them, by the development of industrial and residential parks with multiple open spaces acting as fire breaks. In the proposed dispersal scheme, this

zone of alternating residential and industrial parks would be locat generally in the heavy to medium damage zones otherwise most subjec the threat of fire storms. Although isolated fires may be initiate in industrial and residential parks in this zone, it is extremely u that fire storms could develop. Furthermore, since construction, h new, is most likely of the fireproof type, even isolated fires may comparatively rare. Certainly steps in building codes and zoning c be taken to assure this. Thus it may be concluded that in the medi to heavy damage zone, most blast fatalities may be eliminated by si blast shelters or natural major building basement shelters, provide adequate warning is available - and it can be. Radioactive fallou casualties may also be substantially reduced by either blast shelte or the building basement fallout shelters in the dispersal scheme. point of comparison becomes meaningful only with consideration of t threat of casualties from fire and fire storms. Here there is a cl between highly probable fire storms requiring blast shelters with i nomous air supplies, or only sporadic fires that can be dealt with normal means and, which, in the case of the most probably prevalent of structures in the dispersed residential and industrial parks, a extremely rare. The choice between blast shelters lacking indepen air supplies and the dispersal scheme clearly favors the latter, s the former would fail to protect its population against suffocation choice between blast shelters with independent air supplies and di plus fallout shelters is much more difficult, and must be resolved the basis of relative costs, since both approaches would in this c save most of the population in the medium to heavy damage zone.

Again the cost comparison appears strongly to favor the u dispersal plus fallout shelter approach over that of blast shelter

independent air supplies. On even a direct cost basis, the latter will cost more than the former. But assuming that indirect economic and other benefits, such as economies of transport and other services, accrue more to the system of residential and industrial parks than to continued urban congestion, there is an even clearer payoff in dispersal compared with blast shelters.

The considerations discussed above for the medium to heavy damage zones would appear to hold for the light damage zone also. It is quite likely that the conslusion of cost benefit comparisons would also favor the dispersal scheme.

In consideration of the above factors alone, and assuming that indirect benefits and costs will at least not reverse their comparison, the urban dispersal scheme suggests itself as superior in its ratio of benefits to costs, to that of blast sheltering for continued high density urban concentration. This conclusion does not appear to be markedly sensitive to variations in the relative weighting of the importance of either different zones of the city or of different cost benefits. Furthermore, the proposition is at least defensible, if difficult to demonstrate quantitatively, that the indirect benefits of the urban dispersal approach are superior in their achievement of most agreed-on social values tc those that may obtain from continued and unrelieved urban concentration. . .and this at less indirect cost also, since it exploits and accelerates a natural trend of space redistribution, rather than ineffectually opposing it.

8. HOW DISPERSAL COULD BE ACHIEVED.

As an example of what might be done to re-establish "Towns" or smaller cities, while permitting the larger cities to thin out until they too approach the desireable size, let us consider the cas of Boston and New York. Both cities share the vices of downtown con gestion, slums, inefficient government, and high tax rates. Both cities also share the economic advantages accruing from port status, regional center, and downtown concentrations of business activity, a also certain esthetically satisfying (or at least impressive) downto visual charms (Wall Street, Beacon Hill - of course they are very di ent). The virtues need not be sacrificed substantially to reduce so of the vices, and also reduce the target value of the city. The dow town or core areas of the city may remain. It is the midtown belt o slums, congested shopping districts, and peppered with high-priced neighborhoods that may be "thinned out" without great loss and posit gain. Such areas would include the Devil's Kitchen and Harlem and Downtown Brooklyn areas in New York, and East Cambridge, Chelsea, So ville, Brighton, Dorchester, and South Boston in the Boston area. T industries and people currently located in these communities may in be gradually induced to relocate in a suburban belt of clustered tow ships. The "thinned out" areas remaining would then best be convert to a green belt of industrial and residential parks immediately surr the old city core. The entire metropolitan area would be transforme into a pattern of alternating rings of parks and belt communities, n by circumferential and radial lines of communication, as shown in FI

A gradual and relatively painless method for achieving this urban dispersal and redistribution of population and industry would

to provide strong tax inducements for major industrial employers to relocate or expand into the suburban rings of industrial parks. Popu lation might be expected to follow, if proper zoning practice is main tained by alternating industrial with residential parks in the "green rings. As land values drop in the residual and partly abandoned form high density belts adjacent to the core, these could be purchased by municipal authorities and redeveloped into further green belts of alternating industrial and residential parks.

The minimum size of a community required to realize economic, political, and cultural values will vary with the activities and tastes of a region's inhabitants. Surprisingly, the political and cultural requirements are most likely to be the limiting ones in the future, as the economic utility of industrial parks and suburban shopping centers becomes apparent, and it is realized that the essential centers of such densely concentrated industries as finance, investment banking, garment manufacture, entertainment, and merchandising are rarely very populous by themselves. (There is no reason to suppose any particularly fruitful interaction from the colocation of investment banking and garment manufacture in the same overcrowded community.)

There may be some very difficult transitions from the ward politics of massive voting blocs and urban political control of the balance of political power, to what may revert to state control of critical voting areas as the old concentrations are eroded.

The cultured theater, art, and concert buffs in New York, Boston and San Francisco may find it difficult to envisage communities limited to a few hundred thousand inhabitants accepting the burden of nourishing comparable institutions. How much culture would subsist in Cambridge without the human market of Boston? And yet it seems feasible for communities the size of Cambridge, Massachusetts (120,000) and Oxford, England (100,000) to provide concentrated culture for their entire regions by dint of the presence of great institutions of learning. Thus it appears high culture is compatible with small scale provided there exists functional specialization among the small cities or towns. In any case, there is no reason to insist on the dismantling of the major

cultural centers of civilization. It is only necessary to gradually disperse the associated industries and populations, which presumably will retain convenient access by means of more rapid communications an transportation. The disadvantage of dispersal that appears inevitable and unavoidable would be the loss of the bewildering but stimulating concatenation of culture and commercialism, variety and uniformity, we and poverty, that is a large modern city. Perhaps the price of survi is that high.

Factors tending to permit larger communities at comparable levels of percentage national population survival (always assuming the availability of fallout shelters to all) include the dispersal of strategic military targets in such a manner that they are not within lethal radius of cities, on the national level, and increases in the number of target nations on the international level. The latter devel opment, at least in this context, may be a fortunate result (one of t few) of the diffusion of nuclear weapons and rocket technology. Both the national and international multiplication of targets would tend t reduce the number of weapons specifically allocated for urban communi bombardment. In this connection it may be of interest to note that w a certain degree of reduced vulnerability to surprise attack against strategic retaliatory forces is helpful because it multiplies targets and reduces the probable allocation to cities, much greater decreases military strategic target vulnerability may have the opposite effect. This would be the result of strategic military targets becoming so in nerable to counter-force attack that any missiles expended on them wo be wasted, hence forcing the aggressor to change strategies to nuclea counter-value blackmail (and possible partial fulfillment).

Factors tending to require reduction of community size in order to multiply the number of targets are major reductions in nuclear warhead and delivery vehicle costs. Significant economies in weapon unit costs will make feasible expansion of inventories at constant and feasible budget levels. The absence of negotiated or tacit arms controls or restraints on weapon production will also tend to reduce the maximum permissible community size, since the weapon production race would not be restrained.

DISPERSAL - TO WHAT?

Given the desireability of urban dispersal, to what new form should it be dispersed? More suburbs? More cities? The view taken by this writer is essentially that of Ebenezer Howard, who in the Engl of the early part of this century ventured to actually assemble an experimental "green belt" town. The fundamental concept of the green belt town was that it was a complete civic and urban unit, limited fro exceeding its optimum size or merging with other communities by the "green belt" of vegetation around it. It was not merely the increase in suburban area, or the space devoted to a particular urban function, but rather the development of an autonomous colony that was proposed t accept the surplus from the larger cities. The only major modificatio that the present writer offers is that such communities be established with the current suburban communities as their nuclei, so that they ma more immediately relieve the high and dangerous population densities o the larger metropoli. Howard probably underestimated the social value realized by city dwellers that are not easily achieved in his communit of 32,000. Hence we suggest the urban dispersal to formerly purely suburban communities (to become small towns) that are within easy (les than one hour) commuting range of the metropolitan core. This would seem to permit the best of both worlds.

The New Towns in Great Britain appear to have proven the pure economic and social viability of Howard's green belt concept. Given this demonstration of social effectiveness under peacetime conditions, the added argument of reduced total vulnerability to thermonuclear bombardment would appear to settle the question. This is far from

being the case, however, primarily because the current disutilities and blights of congestion are not sufficiently painful to incur the painful political and economic costs of change.

As the large city declines with military and social obsolescer other centers of community must replace it to maintain economic, politi and cultural values. The cultural ambiance of a nation in which North Beach (San Francisco), Vielle Carre (New Orleans), the Broadway theater and Fifth Avenue shopping districts (New York), and Beacon Hill (Boston were all dismantled and transformed into housing developments or rural shopping centers and industrial parks would be dismaying indeed. It would reject what may be best in the European cultural heritage for something that might be characterized as "Contemporary pastel wild west The economic dynamism of such industries as entertainment, advertising and merchandizing, publishing, investment, and others that depend on multiple interactions on the immediate social level might also be eroded in such a flattened distribution of economic nuggets.

The rejection of the extremes of population distribution by reason of military, economic, political, and cultural requirements sugg a viable compromise that is neither surprising nor new, nor perhaps eve not to be automatically anticipated. It is the reclamation of what may again be called The Town, or small city. The resurgence of the town is here conceived as a return to a more integrated community of economic, political, and cultural activities that fails to represent, in any sing unit, a critical military target, and that in sum present more military targets (substantially more) than there would be weapons to destroy a large fraction of them. The ideal size of the town or small city would thus be the result of a compromise between the minimum size required fo

efficient realisation of economic, political, and cultural community values, and the minimum size representing a lucrative target for bombardment. Both of these criteria are very difficult to develop to a point of widespread agreement.

THE TECHNOLOGICAL FEASIBILITY OF RAPID TRANSIT OF DECENTRALIZED URBAN COMMUNITIES

Whatever the military merits of urban dispersal, to be economically feasible the rapid transit of the population to and from work, school, and shopping must be maintained and, if possible, improved. Temporal economies may be achieved by proximity, speed, or a combinati of both. Since proximity will not always be either desireable or poss speed of movement is essential. The proportion of the population that located near most of its major activity centers may be significant in some cases, thereby reducing capacity requirements on urban rapid tran For that probably larger fraction of the local population not enjoying (or chafing against) this advantage, the problem of rapid urban transi remains undiminished, if perhaps less crowded. Let us therefore exami both the increased distances that may have to be traversed, some reaso able travel times, and the technology required to achieve such transit times.

The common distance between the core city and the suburbs in typical large cities of the United States is seldom more than twenty m (except possibly Los Angeles and San Francisco), and frequently closer to ten miles. In New York it is some fifteen miles from the Manhattan downtown core to the suburban communities in Nassau, Westchester, and Bergen counties. In Boston it is also some fifteen miles from the Bea Hill and adjacent core area to suburban Woburn, Lexington, Newton, Ded and Braintree - perhaps a little less. While it is true that some com muters come from as far as Pennsylvania (to New York) and New Hampshir (to Boston), and an even smaller elite group commutes from Washington, D. C., to both these cities, this 15-mile radius may be taken as the

nominal commuting distance. It is assumed that commuters from Framin Brockton, and Beverly to Boston (approaching twenty miles out) will b balanced by those coming from some ten miles out from Brookline, Belm Medford, and Revere. Furthermore, by no means all persons residing i these peripheral suburbs work, shop, or send their children to school in the core area - increasingly, the contrary is the case. However, us retain our nominal fifteen mile commuter range for this decade. I urban decentralization is accomplished, this distance may increase fi fold for some commuters. From this follow the questions of whether speed can also be increased fivefold, or whether transit time may als be increased, or some combination of the two.

It should be emphasized that the fivefold increase in commu distance is probably much greater than would be required by most, and would, in the case of Boston, probably involve merging the Boston met politan area with those of Nashua, Lawrence, Lowell, Leominster, Worc Providence, Fall River, and Plymouth. Nevertheless, this degree of decentralization would probably be required to reduce lethal target a concentrations to well under 500,000 population.

It may be considered axiomatic that the commuter will not wi to tolerate additional transit time. In those cases where the distan approaches twenty miles today, even with only moderate traffic, the t for transit approaches one hour. Such a commuter gives the equivalen of an additional working day each week simply to personal transportat to and from work, not to mention evening and weekend shopping trips (although these may be either shorter or longer). Although some com are known to enjoy their personal transportation, many find it a cho Also, what may be a pleasant way to wake up while hearing the news o the car radio for half an hour, may turn to utter tedium if stretche

an hour and a half. Let us assume, therefore, that transit time sho not be increased.

If commuting distance may be increased fivefold, and commut transit time is assumed to be at its tolerable maximum (or beyond it then commuting speed must increase fivefold. Is this technologicall feasible? When? How? At what cost?

It is feasible, now at very great cost, or in twenty years modest cost. Today the majority of automobile commuting traffic mov at an average of twenty miles per hour, with legal peak speeds of si It is possible to envisage somewhat modified private vehicles achiev average speeds of 100 miles per hour, with peak speeds of 150. That type of traffic would require new roads, traffic regulations, and at least modifications of today's types of automobiles (particularly ir tires and brakes) is not denied. All of the technology is available today, however, including automobiles not <u>much</u> different from family cars (and identical with commonly owned sports cars with racing tire that can be driven at speeds well over 100 miles per hour, hour afte hour, without undue wear. The most expensive modification that woul required would be the highway system, and in particular its curves a interchanges. This is a matter of planning and economics, because t technology is elementary.

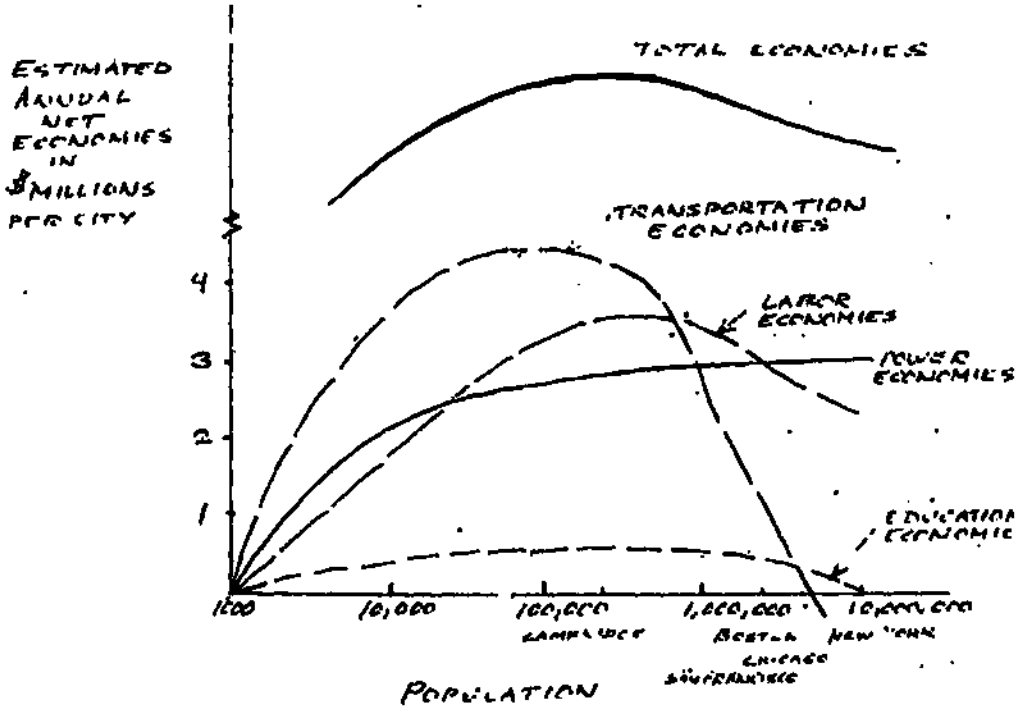
Nevertheless, the private automobile driven at speeds well excess of 100 miles an hour over new superhighways does not appear t this writer to be the most promising solution. To achieve average s of 100 miles per hour, even with few stops and unprecedently clever management of interchanges, peak speeds would have to approach 200 m while the automobiles achieving this kind of performance have been

available for years in the form of racing cars, the drivers are not equally available (in sufficient quantity). Speed of driver reacti becomes limiting, unless such great spacing between cars and such gentle curves are employed that the traffic capacity of the road sy would be much constrained, or maintained at greatly increased cost expansion. Peak legal speeds of on the order of 100 mph., with ave speeds two to three times that of today's twenty mph. appear much m plausible. Automobiles used at this accelerated pace could accomod a large fraction of the commuter traffic. This still leaves us wit the problem of the man who must travel 100 miles, clear across his metropolitan area, to go to work, and for the sake of health and ho must do it in under an hour.

For this "long range" commuter, public transportation may again provide a viable answer. The constraints here are political economic, indeed, but certainly not technological. Conventional el electric express trains in Japan today <u>average</u> well over 80 mph (on one-stop Kyoto to Tokyo run). Not even shiny aluminum monorail car required to achieve average speeds on the order of 100 mph, althoug these would reduce costs. If the political problems of arranging r of-way are too complicated or costly to solve, the long-range commu may find the solution in public transportation by air. Cargo helic averaging over 150 mph. are available today, and could be run like shuttle buses over established low altitude routes. In a few years perhaps less than ten - commercially profitable vertical-takeoff-a landing aircraft (VTOL) may provide three-dimensional transport eve more rapidly and cheaply. While air commuting costs today are high per passenger mile than for public surface transportation. they are

comparable to private surface transportation by automobile. In the future, air commuting will cost less than it does now, while private surface transport costs will increase with performance, power, fuel consumption, tire and braking wear, and insurance costs reflecting increased risk of accident at higher speeds.

The above discussion had been intended not to describe the best future mode of long-range commuter transit in enlarged, decentralized cities, but rather to indicate that there are no particular technological constraints on such a development. Of course in one sense all constraints may be considered technological, in that they are involved with questions of relative cost benefits, which in turn alwa depend at least in part on the efficiency with which space and energy are utilized. This is not the commonly accepted connotation of techn logical feasibility, however. Technological feasibility is more usua concerned with the length of time (and the cost) required to do the basic research, engineering development, and production of a given device. The above discussion should suggest that at least the prototypes for all the vehicles required for rapid commuter transit of large decentralized urban communities are operational today, and that specialized engineering adaption for the sake of improved efficiency could be achieved in a very few years - indeed, in much less time tha the development of decentralized urban communities is likely to requi Hence the conclusion that the technological feasibility of rapid tran is not a limiting constraint on the development of decentralized urba communities.



ECONOMIES OF SCALE AS A FUNCTION OF URBAN SIZE

SOURCE : W. ISARD, LOCATION AND SPACE ECONOMY NEW YORK, 1956

9. CONCLUSIONS.

Recent developments in military technology have not yet made cities obsolete, even in their present forms. For the next few years, fallout shelters such as may be devised within the formal context of contemporary cities will provide as much protection against the radioactive hazards of the most likely counterforce attack, as might be provided by alternate forms of urban organization (except for ports). Once military forces become substantially invulnerable to attack, in the latter part of the decade, the picture darkens. Cities are now likely to become prime targets, and they cannot provide protection for their populations in their current form (within practical cost limits). Fire storms would threaten survival in otherwise adequate blast and fallout shelters, and self-contained cooling and oxygen supplies would be impractical for the numbers of persons involved. The conclusion is that once cities become primary targets for the larger weapons, they must modify their form to survive. The modification suggesting the greatest increase in survival of metropolitan values for the least disruption and cost, while possibly also realizing certain bonus effects of economic, social, and esthetic improvement, is a combination of limited dispersal and local hardening. The limited dispersal reduces or eliminates the danger of fire storms (although not isolated fires) without which economically feasible hardening in the form of blast-fallout shelters becomes effective in all areas except those very close to ground (or air) zero.

Alternative forms of limited dispersal for metropolitan areas include the satellite galaxy, star, ring, chain, and combinations of these. The satellite galaxy and star-ring combination appeal most for their constructive use of the older core as a hub for the organic

development of peripheral concentrations, and the transportation and esthetic efficiencies they appear to promise. Further research, particulatly of a quantitative and experimental nature, may suggest the superiority of other forms. There appears to be little doubt, however, that some form of urban dispersal, combined with hardening, will be required for city survival when cities again become strategi targets.

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