Logistics of National Survival

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Toward the end of the 1950s, with the introduction of intercontinental ballistic missiles, nuclear war emerged as the primary form of emergency in the United States. Although nuclear war kept its preeminent position as the prototypical form of emergency until the end of 1960s, towards the mid-decade a second set of problems emerged around the problems that limited war posed. Conventional and non-conventional wars from a particular perspective were mirror images of each other. While in nuclear war the problem was the decay of a stable order into absolute chaos, in the former case the problem was the reverse: maintenance of a stable order in the face of war mobilization activities that were potentially disruptive for the economy as an autonomous domain. Mobilization under a capitalist economy, as opposed to its counter part under communism, revealed serious obstacles for military and government planners in their practice. They had to find ways of stockpiling and preparing mobilization programs that were sensitive to the autonomy of a set of interdependent autonomous relationships. Furthermore, in the case of stockpiling they were under pressure by budget constraints imposed by the political sphere for a more effective stockpiling program.

As a consequence of this formation, a wide range of seemingly unrelated problems that were articulated under the notion of emergency preparedness practice came into being by the early 1970s. The jurisdiction of Office of Emergency Preparedness (OEP) was extended to problems such as sabotage (i.e. terrorism), labor disputes (strikes), natural disasters, energy crisis, conventional and non-conventional warfare, economic crisis and impact of government programs on the economy. Even riots began to be seen as a potential domain of emergency preparedness and relief.[1] Under this multiplication of and sea change in the categories of emergency preparedness, nuclear war lost its centrality. Scheme of classificatory categories of emergency preparedness was emancipated from nuclear catastrophe as the singular problem for planners and it was replaced by a bi-polar formative space. From an analytical perspective, these problems can be located on a continuum. One pole of this continuum was concerned with catastrophic and sudden events, such as natural disasters, and it was constructed thanks to the problem of nuclear war. Under this category, the world abruptly separated into two states, pre-event and post-event and the shift from one state to the other was sudden and unexpected. The other pole of this spectrum was organized around the problem of reproduction of a stable and autonomous order in the face of potentially destructive activities that are external to this form. This classificatory position came into being as a result of OEP's concern with mobilization for limited war and stockpiling. In contrast to the other pole, there was no singular event to sharply structure the world into temporal states. The emergency as an event, if it can still be thought in these terms, was an anemic state in itself to be modeled. At this pole, emergency was conceptualized as a divergence from the normal state of things, a disruption of an orderly life, and an anomic state which was considered to be a vulnerability. Event and logistics modeling techniques were the prime tools for preparing for the former and the latter forms of emergencies respectively.

[1] Wallace Oliver and David O. Wood, "Industrial Strike Analysis System (ISAS): A Concept for Improved Readiness in Assessing the Economic Impacts of Selected Industrial Strikes," (Office of Emergency Preparedness, 1972). In the early 1970s, riots (especially in D.C.) almost became another form of emergency that OEP had jurisdiction over. Despite the enthusiasm of OEP administration, the Congress and politicians thought that such a classification would create incentives for rioters to use riots as a tool to get governmental funds for riot relief. Recognition of this feedback tool prevented the crystallization of this formation.

Event modeling, as noted above, constructed pre-event and post-event states of the world and compared these two successive states. Logistics modeling, on the other hand, simulated a continuous time span by paying attention to time-phased effects and interdependent relationships and activities. There were no single catastrophic event to be modeled; rather there were an array of simultaneous and interdependent activities. From this perspective, the emergency to be modeled did not have to be external, such as an attack, to the ontology being modeled. From the perspective of logistics modeling, vulnerability was seen as an endogenous property of a given system. As in economic crisis or inflation, the problem could be so diffused and decentralized that there was no single catastrophic event to be blamed. Instead, the emergency could be due to the intrinsic qualities, or the state, of the ontology being modeled. For instance, strikes and, to a certain extent, riots can be seen as these types of emergencies. Workers, which were internal and intrinsic to the production system from a functional perspective, were the source of emergency, since they came to be seen as potential disruptions to an autonomous and stable domain.

In this document, I will try to illustrate how this formation came into being in the decade of 1960 by using what OEP called 'analytical models.' Analytical models can be seen as extremely flexible technologies. They are constituted by sub-models that are modular and black boxed expert techniques, and these modules are assembled together by translating the outputs of a module into an input for an other module. Analytical models were used for purposes of readiness (training), gaming (scenario enactment) and simulation (planning). In the 1960s, even though the idea of scenario enactment was not spelled out explicitly under this term, as a form of potential use it was in the process of articulation. Readiness and planning aspects, on the other hand, were already formulized under the notions of 'National Operational-Readiness Objective' and 'National Resilience Objective'.[2] These models and their classification would be one major way to identify critical thresholds for the emergence of vital systems security as a possibility.

<u>READY:</u>

Ready is defined as "new, extended and more flexible damage assessment system … designed to estimate losses and availabilities due to [any real or hypothetical] nuclear attack."[3] Ready is said to be replacing more limited and specialized models such as JUMBO, STREAK and DART. These models are direct damage assessment simulators. Since both Jumbo and Ready are single attack simulators, they are classified under national operational-readiness objective. While Jumbo is a general damage assessment model, Streak and Dart estimates damage to facilities and casualties specifically due to blast and fallout. Other than technological improvements such as higher calculation speed and capacity, Ready system uses the direct analysis of Jumbo as input for more extended analysis procedures. This can be interpreted as an initial step towards logistics modeling from models dominated by event modeling rationality. Ready model assumes that the attack will consist of only one detonation and the model is concerned only with the supply side and the productive capacity of the industry. First, it simulates the attack, and

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[2] James C. Pettee, "RISK II: A General Vulnerability Analysis Model," in *NREC Programs for Gaming the Logistics of National Survival* (National Resource Evaluation Center, 1965), 33-4.
[3] Irving Gaskill, "READY: Gaming Resource Losses and Availabilities," in *NREC Programs for Gaming the Logistics of National Survival* (National Resource Evaluation Center, 1965), 3.

then translates the attack into damage. Damage is translated into casualties and resource availability in the direct and extended analysis. For modeling purposes, casualties and resource availabilities are treated epistemologically equivalent, since both of them are seen as *things* upon which damage is exposed.

The model has two main parts from a functional perspective: Attack simulation and damage analysis. Attack simulations can be located within a military practice devoted to war planning and strategy development. Such an expertise required the analyst to know the enemy, its capabilities and the possible ways in which it can act. Different combinations of these items constructed different scenarios of possible enemy attack. In the case of Ready, the user can either manually select a possible locale that is thought to be the target of enemy and also mark the points of interests pertinent to the exercise, such as strategic resources, production facilities and critical infrastructures, Attack I model will generate an attack scenario.[4] In this mode of scenario construction, in contrast to the Risk model, the future is determined still to a large extend by the user rather than the machine. Even if the Attack I is used to generate the scenario, only a single future is envisioned. Although damage computation and success of the attack are conceptualized with the help of probabilities, the strategist's vision of the future constitutes the future as a single and certain state of the world.[5] Finally, deviation from the anticipated ground

[4] p. 37, "Analytical Program Compendium" NREC Technical Manual No. 119, 1964. For Attack I, see page 2.

[5] As it will become more clear in Risk model, the successor of Ready, scenario construction will be left to the machine thanks to the introduction Monte Carlo technique. In this mode of thinking, the future ceases to be a single state and a multiplicity of probable futures are constructed. This model allows probabilistic thinking to gain autonomy from the sovereign and deterministic gaze of the analyst.

zero is calculated due to wind effects. Attack simulation, thus, can be seen as a step toward automation of scenario expertise.

What is interesting about the application of scenario modeling in the OEP's analytical models is its convergence with nuclear warfare, especially with the introduction of intercontinental missiles. Switch from conventional to nuclear warfare meant widening of the gap between the aggressor and the consequence of his actions. In other words, in conventional warfare, one can assume that there is a direct correlation between the intentions of the actors and the effects of their actions. However, in the game of nuclear war with intercontinental weapons, first, the scenario development has to be adjusted to the rules of such a game. Second and more importantly, nuclear attack and its effects cease to be dependent upon a pure human intentionality. From a modeling perspective, the intentions of the enemy become one of the inputs for the simulation of the attack. Other factors such as meteorological conditions and uncertainties due to technological shortcomings also have to be taken into account in the simulation of the attack. Furthermore, weapon's effects are mediated by complex processes such as weather conditions and fire-spread factors due thermal radiation depending on the geography and the inflammability of the environment.

Event modeling in this respect destabilizes the epistemic autonomy of the spectacle of nuclear explosion as a singular event by modeling the event as a chain of complex processes. From a lay and public perspective, nuclear explosions can be characterized as events that are to be fascinated with and terrified from.[6] This fascination treats the event almost as unintelligible and ontologically autonomous from its environment. However, from an expert perspective this can be seen only as a very crude

[6] Quote Masco

characterization of the nature of such an event. Preparedness models such as Ready integrated this form of event modeling into attack simulations. Ready used two sub-models for this purpose: Flame and Dusty. These two sub-models simulate the distribution of radioactive fallout and the spread of fire by thermal radiation due to fireballs of nuclear detonation.[7] Both submodels use an archive of past weather patterns to estimate the mediating conditions under which the event will take place. For fallout analysis, it uses US Weather Bureau's upper wind data and for firespread analysis factors such as cloud cover, visibility and surface moisture data are used. Once the attack is conceptualized as a function of such non-human mediators, the event becomes a complex process as opposed to a simple and singular explosion. The effects of radiation distribution and firespread are mapped on a vulnerability map, and supply the inputs for the Jumbo damage computation model. From the machine's perspective, then, a nuclear attack and its effects are not only a function of a rational enemy and its capabilities, but also the weather conditions, the quality of the terrain and geography upon which the event takes place.

From the machine's perspective, the function of the attack simulation is to translate an imagined event into machine language. This translation is achieved through digitization of a qualitative series into a quantitative series. Once digitization is accomplished, the machine feeds the outcome of the attack simulation into the damage assessment module as input. Damage is calculated as a combination of three factors: damage due to the detonation itself, fallout and residual radiation and uncontrolled fires. The latter two factors were fed by Dusty and Flame submodels, and the former is calculated as a function of distance between the ground zero and the location of the

[7] p. 7 & 9, "The Role of NREC in Emergency Preparedness" by Joseph D. Coker, 1965.

resources under consideration. Damage due to the detonation itself is damage due to blast, shock, and thermal and nuclear radiation.

Knowledge regarding the effects of nuclear weapons constitutes another genealogical thread of event modeling. Thanks to the military experiments such as blast tests in the 1950s, Ready model could utilize this technical knowledge to estimate the damage inflicted on precise items in the post-attack state of the world. In these tests, experts were interested in finding materials' inherent qualities in terms of how they interacted and responded to different externalities. Some of the externalities to which materials were exposed to were pressure, radiation and heat due to blast, fallout and fire respectively. The changes in the form of the material after the test were conceptualized as deformation and damage.[8]

In the analytical models, weapon effects series is collapsed onto another series that contains the data on resources chosen by the user. Damage is conceptualized as the collapse of these two series into one. For each resource point, the probability of severe, moderate and light damage are calculated due to blast and thermal ignition. Also casualties from blast, thermal and nuclear radiation are calculated by taking into consideration the population densities. Damage then becomes a function of the specific location of the point, vulnerability of the resource to the specific damage type and the yield of the weapon. The combination of these two series produces the post-attack state of the world.

This level of damage analysis is classified as a direct and point analysis. It is called direct, because damage—which is not yet thought as vulnerability—is

[8] One hypothesis would be that each material's response to a given level of external stimulus varied. Then the response to stimulus, i.e. damage, was a probability distribution. This would explain why damage analysis models used probability to indicate the expected damage on points of interest.

conceptualized as the direct effects of the event on the objects in the world. And the ontology of the world is conceptualized by the machine as a group of singular and independent points that have inherent qualities that determine their degree of vulnerability in the face of the attack. In this mode of damage analysis, damage is thought in terms of absolute values of resources, including the manpower, available for use. There is no attempt at conceptualizing damage at a spatial or temporal level, and the interrelationships between different items and units are ignored. The object of analysis is materials and objects, and the scale through which such analysis is quantified is quantitative amounts of resources available. In this respect, Ready does not assume the existence of a deeper structure at the ontic level beneath the surface of the ontology simply consistent of things. Therefore, it does not worry about identifying vulnerability as the aggregate effect of damage. For Ready, damage is only conceptualized at the individual point level. From a systems perspective, point analysis is restricted only to the nodes of a network and does not take into account the interdependencies of production as a system. Ready is mainly concerned with static things, whereas in PARM the object of analysis is dynamic activities.

Extended analysis programs of Ready take the results of the point analysis as its input and extrapolate indirect effects of the event. These programs are multiple resource analysis, effects distribution, network area denial and PARM analysis. Multiple resource analysis and effects distribution show the interdependencies among different resources and allows the analysis to have a more critical understanding of damage. Network analysis concerns itself with the time-phased denial of utility resources such as electric power. Finally, PARM assembles all these different types of analysis together to estimate the available production capacity under the constraints of network denial and manpower due to casualties. Since extended analysis of Ready is mainly concerned with immediate production capacity right after the attack, the analysis does not need to take into account vertical dependencies among sectors and time-phased synchronization problems that only unconceal themselves in an analysis at the long-term temporal scale. Even though extended analysis programs of Ready carry the fingerprints of logistics modeling, these techniques hold a very marginal place in Ready and the way in which they are employed are very premature in terms of their autonomy from event modeling.

Risk:

Even though Risk is predominantly an event model overall, it is a very critical threshold for the conceptualization of vulnerability from a systems perspective, and it is the fundamental tool for national resilience objective. The shift from Ready to Risk marks also the shift from damage assessment to vulnerability analysis. Analytical Program Compendium of NREC/OEP explicitly classifies these models under the categories of damage assessment and vulnerability analysis respectively.[9] Preparedness to nuclear war from a resilience perspective obligated realistic modeling of nuclear war as an event which meant single attack scenarios became obsolete for such a purpose. Under the resilience objective, vulnerability was rearticulated as the minimum *aggregate* damage to critical resources and infrastructure of the nation. Once damage was

[9] "Analytical Program Compendium: NREC Technical Manual No. 119," in *NREC Technical Manual* (National Resource Evaluation Center, 1964), iii.

conceptualized from a systems perspective, vulnerability analysis models such as Risk replaced damage assessment models.

According to James Pettee, Deputy Chief of NREC, there are two distinct aspects towards the objective of emergency planning. The first is 'national operational-readiness objective', and it involves "improving the ability of the government to cope with its post-attack responsibilities." This objective required the government to develop analytical preparedness and train the personnel who would be critical in the post-attack situation. The simulations with a single attack conceptualization such as Ready were developed towards this end. Their function in emergency preparedness was "to increase the proficiency of the participants in the pursuit of operational readiness" for exercise purposes.[10]

From this perspective, single attack simulations were enough to familiarize the experts with emergency practices. However, these simulations also contained a promise and a potential within them for simulating the totality of a future event realistically. This also meant a shift in the purpose of these simulations from purely training purposes to preparedness purposes. Training simulations offered the experts a future that is hypothetical and imagined. The simulated future was only one scenario among many others. For these reasons, the simulation could afford to ignore a <u>realistic</u> criterion of plausibility. This meant that there was no effort to replicate the ontology of the real world in the simulated scenario. Certain complexities such an effort would require to face were simply ignored. For instance, one of the reasons why Ready was a single attack simulation was a technical problem that would be addressed only if a multi-attack

[10] p. 33-4, "The Risk II Model: The Spectrum of Solutions in Logistics Gaming" by James Pettee in "NREC Programs for Gaming the Logistics of National Survival", 1965.

scenario on a national scale was envisioned. Since nuclear radiation was an immensely complex phenomenon, the developers realized that simple probability rules for estimating the combinational effects of multiple detonations were not appropriate in the case of realistic planning for nuclear war.[11]

Realization of these technical limits as constraints and the emergence of these constraints as obstacles hinted towards the formation of a new mode of planning rationale. In 1965 Pettee puts this as 'national resilience objective'. This objective meant a pre-emptive approach to planning, and it was organized around direct and indirect approaches. Direct approach was concerned with "changing the physical condition or location of existing resources." Indirect approach, on the other hand, aimed at "increasing the built-in resilience inherent in the on-going pre-attack economy." Enlarging the overall national economic potential or making the economy more flexible and self-adaptive to change were seen as major means for indirect approach. Indirect approaches to national resilience objective necessitated evaluation of government programs and activities through simulation of the national economy twice, with and without the proposed program.[12] One has to note here that even though NREC and OEP were aware of the impracticality of simulation of an entire economy,[13] this approach was employed, though in limited scope, under the Economic Impact Group of OEP for surveillance of the impact of war mobilization on the economy.

Risk was a tool that was developed under the ethos of direct approach to national resilience objectives. Its purpose was "to change the severity of any post-attack problems

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11 Cite

12 p. 35-7, "The Risk II Model: The Spectrum of Solutions in Logistics Gaming"

13 Even in the early 1970s, they were skeptical, though enthusiastic in principle, about Rockwell Corporations proposal for the simulation of the entire economy. Give citation and names…

with which the government may have to deal [in advance].” Single attack simulations could not provide the necessary guidelines for this purpose, since they deliberately did not pay enough attention to the complexity of the ontological state of the real world. A mode of planning at the order of preparedness necessitated “the analysis [to] include a simulation of the full spectrum of possible attack effects distribution pattern any of which are sufficiently plausible as a possible outcome in the event of attack.” Also the refusal of independence of the events (nuclear bomb detonations) from the perspective of probabilistic analysis implied a conceptualization of the ontology from a systems perspective, since the constitutive assumption of a system is the assumption that the elements of a system are interdependent and, therefore, ontic relations exists underneath things that give system properties to the totality of things that constitute the ensemble of relationalities as a system.

Thus, two envisioned nuclear detonations could not be thought as independent events as in the case of flipping two separate coins. Whereas in the latter case two events would not interact with each other and therefore affect the aggregate outcomes, in the former case “the probability dimension with regard to the geographical distribution of attack effects in the event of attack” had to be taken seriously.[14] The estimation of probabilities for this reason could not be done through simply summing separate probabilities pertinent to each event. Rather, they had to be treated as complex and dependent events upon each other. According to the developers of Risk, this however is no easy task, since such estimation is immensely complicated and complex.

Risk II model utilized this new approach by introducing ‘summary analysis of probability.’ Similar to the Ready model, Risk I was restricted to point analysis which

[14] Cite

estimated the probabilities of hazard at a single geographical location. Summary analysis, on the other hand, estimated probabilities of hazard for multiple points simultaneously. While in the point analysis, the damage of a point does not take into account the damage on other points, summary analysis accounts for "the simultaneity of the attack impacts among the points."[15] By conceptualizing damage and its level probabilistically, another step towards conceptualization of vulnerability from a systems perspective was taken. Hazard became a function of "complex geographical points among the points of any selected group and the likely targets." Once vulnerability is conceptualized in terms of relationalities and dependence among a set of points as opposed to pure physical damage on a given point, preparedness operations can be employed on the organization and configuration of these points so that the aggregate damage upon them is minimized. While a straight minimization approach would attempt to minimize the *sum of damage* inflicted on all points as Ready would do, a critical optimization approach would conceptualize damage at a systems level and, therefore, minimize the damage at the *aggregate* level, which would not necessarily mean minimization of the total damage. By manipulating the configuration of these points the least vulnerable and most optimum system to assure least vulnerable post-attack state can be achieved which is precisely the objective of national resilience objective. It is interesting to note the affinity of this problem with other problems of air and naval warfare that Galison points as the birth of cybernetics. From a cybernetics perspective, vulnerability should be located at the aggregate level as opposed to the individual points. And the aggregate level vulnerability does not equal to the likelihood of physical damage at the individual point level. Thus, preparedness had to operate at this reflexive aggregate level in order to enhance

[15] *ibid*. p. 44.

structures that were thought as the key in survival in the post-attack state of the world. A silhouette of the vital systems security seems to emerge.

Such an obstacle from a technical and engineering perspective, however, turned out to be a productive one from a techno-political and social perspective. One could argue it constitutes one of the formative thresholds for the birth of vital systems security as a security dispositif and paradigm. Not only it pushed a systems-like conceptualization of the ontology, but also it opened up a space in which a new conceptualization of the future could emerge. This new conceptualization of the future marked the emancipation of probability from the science of statistics. While statistics required the observation and recording of the occurrence of events in the past for the prediction of the future through translation of the frequency of the past events into probabilities, this new technique circumvented this archival approach that depended upon the occurrence of events in the past. Instead, the future was produced through the extrapolation of an archive that was consisted of events that have not taken place yet. In other words, instead of collecting data regarding the past to understand the future, this new technique simulated a variety of the future states of the world n times. The inverse of the frequency of each outcome out of n trials gave the probability of such an outcome happening in the future. This production of the future meant that the simulated event and its effects had to be simulated realistically as opposed to the aggregate and post-ante approach of statistical archiving both of which black boxed such a realistic simulation. With emergence of this novel technology of the future, certainty of a pre-determined future lost its privileged position in planning practices to uncertain and probabilistic *futures*. These futures were modeled as parallel and alternative states of the world and they were epistemologically equivalent to each other even though they were not necessarily equivalent in their likelihood. Emergence of this new science of the future can be seen as a non-discursive formation that will make possible the scheme of preparedness under the motto of 'prepare for the worst case scenario'.

The genealogy of this new technology goes back to the experimentations for the development of nuclear weapons.[16] Since scientific experiments are based upon the assumption that the conditions of the experiment have to be controlled, nuclear experiments, especially in the case of hydrogen bomb posed a new problem for science. For the hydrogen bomb's fusion reaction to take place the experiment required so high levels of energy that those conditions could be reached only if an atom bomb was used. This meant that under physical conditions the experiment was unfeasible to conduct. This restraint led the scientist to construct the conditions of the experiment virtually with the help of a computer. This marked the birth of simulation as a technology and this particular simulation was named Monte Carlo.

One of the first applications of Risk II was Nuclear Attack Hazard in Continental United States 1963 (NAHICUS 63), and later HAZARD was scheduled for years 1967 and 1970.[17] For NAHICUS 63, 6 attack designs were developed. Similar to Ready model, Risk also requires blast damage and fallout effects for the simulation of vulnerability analysis. To each weapon an a priori probability of success and failure is assigned. The success and failure are denoted by 'penetration rate' and 'abort rates'. The sum of these rates gives 100. Monte Carlo generates a two digit pseudo-random number and compares this number to the abort rate specified with the particular attack design. If the generated

[16] see Peter Galison's…

[17] "National Resource Evaluation Center," (NREC, 1966).

number is larger than the abort rate, then this means that the attack was successful and, therefore, the weapon effects the continental the United States. For each penetration, the machine calculates the adjusted ground zeros due to wind effects. Monte Carlo runs N trials (usually this is either 100, 500 or 1000) and randomly selects different attack designs. As a result the model, reports the probability of each attack taking place and their rate of success. For each successful trial, the machine estimates the adjusted ground zeros out of 128^2 possible points.[18] The justification of Monte Carlo technique is based on Central Limit Theorem which assumes that as the size of the sample increases, the distribution approaches the normal distribution.[19]

Monte Carlo simulation's function in Risk, from the machine's perspective, was to transform the pre-attack state of the world (input) into the post-attack state of the world (output). Risk used Monte Carlo's output as input for its analysis programs. Apart from point and summary analysis programs, the model also did analysis on the vulnerability of critical networks, such as pipelines, railways, highways, waterways and communication nets, food balance programs and supply-requirements programs.[20]

Logistics Modeling:

[18] p. 1-11, "An Analysis of the Reliability of the RISK II Computer Statistical Model: NAHICUS 63 Application" NREC Technical Report No. 22. Report the results.
[19] *ibid.* p. 50
[20] "Analytical Program Compendium: NREC Technical Manual No. 119," 4-8.

Possibility of nuclear war on the horizon posed experts to a new, difficult and complex problem in terms of post-attack recovery that no previous war had posed before. Planning experts from National Planning Association under a contract to develop PARM model argued that such a problem required a centralized decision making process with a skeleton staff for controlling the use of critical resources towards nationally essential objectives for national recovery as opposed to locally desirable projects.[21] The problem of recovery posed two distinct, but interrelated, problems which operated at different temporal scales: On the one hand, there was the problem of survival under the post-attack conditions, and on the other hand a full recovery meant much more than the immediate survival of the surviving population. The former problem, due to the properties of living beings, had to be thought in a short-term temporal and local spatial scale. Surviving population had to be fed, secured and sheltered, and since the likelihood of emergence of isolated islands of survival after the attack, these requirements had to be met with the locally available resources. This imposed a temporal and spatial constraint on the satisfaction of these needs from a resource management perspective. The latter problem, however, was operating on a longer-term temporal and spatial scale, which realized short-term assumptions were unfitting for the problem at hand. As opposed to the problem of survival, the problem of full recovery of productive systems of the nation necessitated a long-term and national scale for the model to operate on. This also marks a shift in the object of concern of the models from the wellbeing of the population into systems vulnerability.

Systems vulnerability found the analytical capabilities it required in logistics modeling as opposed damage analysis. Even though models dominated by event

[21] "PRAM: Final Report to the Office of Emergency Planning," (National Planning Association, 1964), 2.

modeling such as Risk could assess the vulnerability of a given configuration of targets, event modeling did not have a positive and substantial definition for systems and, therefore, systems vulnerability. Risk conceptualized and measured vulnerability only as an effect, whereas logistics modeling could develop tools for modeling the system itself positively. From the logistics expertise, the object of recovery was not so much the living beings or resources; it was rather an orderly functioning of a set of interdependent activities. Even if the wellbeing of the population was an object of consideration, this was due to their constitutive role within these activities as opposed to the goal of enhancement of their wellbeing as an end in itself. Thus, logistics modeling once again re-conceptualized security from an aggregate vulnerability perspective in terms of the capabilities of the US to respond back to a surprise attack and the ability to sustain a mobilization effort without disturbing the economy within the nation. All these tasks were categories under indirect resilience approach.

Survival:

Survival is a simple supply-requirements analysis model. It uses damage analysis programs such as Ready and Risk to construct the post-attack state of the world. Initially it was also devised as a single attack simulator. The OEP report indicates that it is being adapted to the Risk II multiple attack simulator, but we do not have any evidence if this has been achieved or not. Even though Survival is a simple supply-requirements analysis, it is significant for two reasons. First, although it is developed as a response to the danger of nuclear warfare, it has a distinct genealogy from hazard analysis models such as Ready and Risk. In logistics models, damage analysis loses its central position and it is black boxed as a module that produces the input data. The problem ceases to be assessing the vulnerability to nuclear attack. The new problem rather becomes given the post-attack state of the world whether survival can take place or not. From the perspective of this new problem, damage analysis tools can be seen enough for the estimation of supply side of the analysis. Survival, in addition to the supply side, introduces demand side and compares these two in a time-phased fashion. In this sense, Survival can be seen as the link between Ready and PARM. This new object of analysis adds a new dimension to emergency preparedness. For the first time, a domestic (or non-militaristic) concern gains relative autonomy in contrast to the hazard models. Second, Survival model is interesting in contrast to PARM model. The relationship between PARM and Survival is homologous to the relationship between Ready and Risk from a systems perspective, since there is no conceptualization of vulnerability in this model. Even though Survival takes into account time phased relationships among the production of goods, it has no sophisticated analytical technique to employ to uncover the systems properties of production. PARM, on the other hand, employs Leontief's Input-Output Analysis towards this purpose. This will be discussed more in depth below under the section on PARM. For this section, it should be enough to say that in Survival the supply is not mediated by this critical analysis technique and this can be seen as the main distinction between the two models.

Survival is classified as a short-term analysis tool, since it only accounts for immediate needs after an attack. The model defines certain commodities as 'survival items'. Survival item is defined as "those items without which large segments of the population would die or have their health so seriously impaired as to render them both burdensome and non-productive."[22] Since survival imposes requirements that have to be met in a short-term scale and often times these requirements have to be supplied by local resources, Survival model operates on a short-term temporal and local spatial scale. Due to these constitutive elements in the conceptualization of the problem, the model does not feel the need to account for vertical supply problems which have to take into account systems constraints inherent to the production architecture due to inter-industry dependencies. These latter systems properties only come out to light once a long-term temporal and national spatial scales are introduced as the constitutive elements of the problem at hand.

Program Analysis for Resource Management Tool (PARM):

[22] Cite!

PARM is said to be the milestone for NREC in terms of the expansion of its role in pre-attack emergency planning and post-attack resource management in conjunction with OEP.[23] Purpose of PARM in the 1959 contract was stated as "developing and furnishing the government procedures for the development of a system for expediting post-attack resource management decisions … [with] the aim of … determining acceptable, or preferred production program, within the limits of the surviving resource levels, during the first two years following an enemy attack upon the United States." The revised contract in 1969 added that "The contractor will further take additional measures to broaden the entire system … to one directed generally at production and requirements matching … that will assist in assessing and coping with the impact on the economy of a major change either in the final demands or in inter-industry relationships." This meant the scope of the model extended from solely being for nuclear war to assessing "the impact of any major changes in final demand associated with disarmament, arms control, economic warfare or other cold war measures, with mobilization for limited war, with such peacetime changes as major public works programs or economic recessions."[24]

One could see PARM as another threshold to be passed. If Risk is the prototypical model for direct resilience approach, then PARM can be seen as the prototypical model for indirect resilience approach. The fact that OEP and NREC had considered integrating Monte Carlo simulation to PARM for the satisfaction of realistic simulation criteria can be seen as an evidence for this claim. On the one hand, from the perspective of vulnerability, it can be characterized as holding a place homologous to RISK in contrast

[23] "NREC's Expanding Capabilities to Support Resource Management," (1965): 1-2.
[24] "PRAM: Final Report to the Office of Emergency Planning," 1.

to Ready. Similar to Risk, PARM also departs from a conceptualization of vulnerability merely as pure damage to resources and production facilities; rather vulnerability is conceptualized as the nation's inability to recover from nuclear war, continuity of government in the post-attack phase and mobilize resources and production to strike back. With the introduction of Input-Output Interindustry model, PARM recognizes the ontological complexities that emergency planning requires the analysts and developers to face. On the other hand, from the perspective of domains in which emergency preparedness appears as a problem, development of PARM also implies another step taken towards the expansion of the practice of emergency preparedness to new domains other than preparation for nuclear war.[25] By the beginning of the 1970s, OEP had extended its jurisdiction to non-militaristic domains such as the economy, the political and the nature. Economic surveillance programs started in the second half of the 1960s led OEP to administer the Wage Price Freeze under Nixon administration; riots and strikes began to be seen as problems pertinent to preparedness and mobilization for war, and natural disasters such as tornados became a site upon which preparedness became a problem and a practice. Considering this sea change from the problem of nuclear warfare to an array of problems in which nuclear war was merely one form of problem for preparedness practices, the fact that in contrast to damage analysis models PARM's primary and central concern is the economy as an autonomous domain constituted by relationships and interdependencies among constitutive activities should be seen as a significant moment of formation. OEP projects that utilized successor models of PARM, such as SPIM, Recovery and Strength, were instrumental in the construction of the second pole of the conceptual space of emergency.

[25] "National Resource Evaluation Center."

From an analytical perspective, PARM can be conceptualized as an instance of assemblage of three distinct modes of thinking.[26] One genealogical thread is Leontief's Input-Output models. Leontief's *The Structure of American Economy* (year) demonstrated the potential of I/O modeling for economic planning purposes. I/O technique is based on a very basic and fundamental mathematical form: matrix. A matrix can be seen as a simple way to store data in quantitative form. A typical n dimensional matrix has n axis. For instance, a two dimensional matrix is constructed by rows and columns. In I/O modeling, columns store the input value for the production of commodity y and rows represent the output of commodity y. Since the goal is to map the totality of an economy in interindustry modeling, each output is either also an input for another commodity or a final consumption good. The ability of I/O modeling to bridge the gap between final commercial consumption with interindustry production relationships allowed economic planning experts to criticize the economists and their dependence on GDP as a planning and forecasting tool by late 1960s at OEP. From an engineering perspective, GDP was an abstract and aggregate indicator and due to this reason, it could only represent the tip of the iceberg if the analogy is appropriate. Unlike I/O modeling, it was totally blind to non-commercial consumption relationships. It was an analytical tool only appropriate for an economic understanding based on conspicuous consumption. As an OEP expert indicated, "From a planning perspective, it was a blinding speculative tool."[27]

With the introduction of computers, the I/O modeling began to construct matrixes that were not possible to construct before. Now, a matrix 128 by128 was possible and

[26] For the historical development of PARM, see Marshall K. Wood, "PARM--An Economic Programming Model," *Management Science* 11, no. 7 (1965).
[27] FIND CITATION!

such a large matrix made possible the idea of tracing the totality of all relationships in an economy. This new technology allowed the experts to trace the effects of a minute change in the price or the quantity of a single commodity on the entirety of the economy. Not only economy was now visible, but also it had gained systems properties. A sustainable war under capitalist democracies required overcoming this new obstacle. Now, military experts, unlike in the case of sovereign power, had to devise strategies to mobilize resources in an economy without disturbing the order in an autonomous economy. Stockpiling was one of those strategies.

What especially interesting about the matrix as a mathematical form is the fact that it is the technical foundation for analytical techniques such as linear programming and network analysis other than I/O modeling. It is already known that Dantzig's linear programming came out of I/O modeling and it also uses matrix as a basis for analysis of relationships and the effects of constraints on these relationships. Network analysis also uses matrix as to store network relations among nodes. If two nodes are connected to each other, then 1 is given to the intersection of the column and row of these two points. If they are not connected, then the slut takes the value of 0. What is significant about this technical similarity is the fact that all these analytical tools were developed by NREC for emergency planning, and especially towards the end of 1960s, they became the central analytical tools for OEP.

The second line of genealogy is intimately connected with the birth of linear programming. Air Force faced with organizational problems with immense complexity in planning air war campaigns in the Pacific during World War II. Air war turned out to require coordination of many activities that had to be operated simultaneously. Marshall

Wood and George Dantzig were central figures in thinking about organizational problems at such scales. In 1948, Planning Research Division was created with the direction of Wood in order to "develop and apply computers to the problems of military logistics planning."[28] Under Scientific Computation of Optimum Programs (SCOOP), linear programming by Dantzig was invented as a generalized form of Leontief's inter-industry model. However, as Wood points out it was not enough for the problems faced in the face of organizing interdependent complex activities. A complex operation based upon synchronization of interdependent activities such as airlifting by the Air Force led to the invention of a new technique: dynamic programming. PARM utilized this technique invented only after the World War II. Wood and Dantzig defined the totality of the activities, in this case airlifting, as an ensemble of interdependent activities within an economy of resources and organization. Under the constraints of limited resources and productive requirements, the model sought to maximize the objective function.[29]

According to Wood, these two lines of development were assembled together under the government-wide Interindustry Research Program of 1948-54 which resulted in 'Emergency Model'. Emergency model, an ancestor of PARM, under the ethos of sustainable limited warfare was applied to the industrial mobilization planning problems of Korean crisis as PARM was thought to be applied to the Vietnam contingency.[30]

One must keep in mind that Emergency model was produced for mobilization problems under conventional war. With the advance of delivery technology for nuclear weapons in the 1950s, namely intercontinental ballistic missiles, another genealogical

[28] Wood, "PARM--An Economic Programming Model," p. 620.
[29] Marshall K. Wood and George B. Dantzig, "Programming of Interdependent Activities I General Discussion," *Econometrica* 17, no. 3, 4 (1949): 193-4.
[30] War mobilization and its impact on the economy, including critical stockpiling, was a major topic of research at OEP in the second half of the 1960s.

thread is assembled with the previous two lines. In 1960 at the 7th International Meeting of Institute for Management Sciences', Wood, then at in the National Planning Association, began his talk as follows:

> I have chosen to talk to you this evening about the security dilemma because it is clearly the most crucial problem facing all mankind today; and because I believe that management scientists could make a major contribution to its solution. … I believe that with respect to the national security problem *as a whole* a more inclusive application of a systems approach is called for. The same rigorous analysis of interaction, weighing of probabilities, and testing of alternative courses of action against both objectives and contingencies, which characterize management science in more easily delimited problems, should be extended to this great issue of national policy.[31]

Throughout his talk, Wood tried to demonstrate the inevitability of nuclear war due to either intentional Soviet aggression or mere accident. Using a game theoretical mode of reasoning, Wood revealed the asymmetry between the US and the Soviets in terms of nuclear weapons capabilities and possible rational choices regarding whether nuclear war was preferable or not to either side. The US was unwilling to deploy a surprise attack on the Soviets. This meant that whether the US was superior as a military force was irrelevant, since it lacked the operational and technological capability to strike back immediately in the face of a surprise Soviet attack.[32] Consequently, effective military capabilities of the US should have been measured only after the attack took place. This

[31] Marshall K. Wood, "The National Security Dilemma: Challenge to Management Scientists," *Management Science* 7, no. 3 (1961): 195.

[32] This comparison was based upon the fact that the entire nuclear capability of the United States was dependent upon long range air craft, while the Soviets had already developed very effective intercontinental weapon delivery systems. This meant that while a US surprise attack would take from 4 to 8 hours, for Soviets this time frame was less than 30 minutes. *Ibid.* 197.

meant in turn that unless the US prepared for a nuclear attack so that its war capabilities can survive the attack, a rational enemy would chose a surprise attack against the US. Wood supported this conclusion further by pointing out the advances in the Soviet ICBM's accuracy and the expected rapid increase in their numbers whereas the US was heavily dependent upon long-range bombers for a nuclear attack on the Soviets.[33]

What is significant about Wood's mode of problematization is his linking of a systems approach to vulnerability under the rationale of emergency preparedness.[34] In Wood's framework, nuclear warfare is characterized as an inevitable problem to which one can only be prepared for. Even if the US builds up the militaristic capacity to strike back and, therefore, dissolve the asymmetry of surprise attack from the Russian perspective, there is always a risk of nuclear annihilation contingent upon a mere accident or misunderstanding. Under the risk of total annihilation of human kind, however small such a probability is the risk of such a catastrophic event happening would be unbearable. Thus, the introduction of intercontinental delivery systems introduced an irreducible element of chance and indeterminacy by changing the temporal structure of such an event. With missiles, total destruction was a matter of minutes which meant readiness prior to the attack was key to survival. The only way to assure survival was to be prepared to such an attack. From this perspective, nuclear warfare can be seen as the prototypical form of emergency which in turn was fundamental in the formation of emergency preparedness as a mobile scheme. Even though other forms of emergencies such as natural disasters were potential candidates for being the prototypical object of

[33] *Ibid*.: 199-200.
[34] See Daniel Wright, Matthew J. Liberatore, and Robert L. Nydick, "A Survey of Operations Research Models and Applications in Homeland Security," *Interfaces* 36, no. 6 (2006). It is interesting to note that Wright et. al. trace back the origins of OR's interest in emergency preparedness back to Wood.

such a problematization, one could argue that they could not pass the threshold of formation since they could not pose such an irreducible and unmatched danger to the survival of humankind as nuclear weapons did.

Then, one possible hypothesis regarding the sea change regarding the domains upon which emergency preparedness was practiced can be attributed to the failure of the assumption that a Soviet attack on the continental US was inevitable and immanent. In 1960, Wood had already argued against the assumption that under a bipolar nuclear power structure "a nuclear strike by either side would result in mutual suicide, and that there is therefore little danger of premeditated nuclear war."[35] According to Wood, not only from a strict military perspective a surprise attack could be a rational strategy, but also once a third nation, i.e. China, acquires nuclear weapons along with submarines with ballistic missiles, strategy of deterrence becomes obsolete, since it is impossible to identify to whom the missile belongs if the missile is launched from a submarine.[36] Finally, from the perspective of communist ideology, Wood argued, preemptive nuclear strike was an attractive option for the Soviets and Maoist China.[37] As time passed, it must have been harder to hold such a position regarding the immanence of the attack. Though still a possibility, nuclear war then would be seen just as one form of inevitable disaster to be prepared for.

Introduction of nuclear war as an immanent threat to national survival assembled a third line of genealogy with the former two. This new mode of thinking was event modeling. As I have already discussed under Ready model, event modeling consisted of two main parts: attack simulation and damage analysis. This technique had originated

[35] *Ibid*.: 197.
[36] *Ibid*.: 203-4.
[37] Marshall K. Wood, "Remarks on Anatol Rapoport's Paper," *Management Science* 7, no. 3 (1961): 226-7.

under a sovereign and military mode of power and was concerned with estimating absolute damage inflicted on resources and production facilities. In contrast to vital systems security, vulnerability was conceptualized in terms of quantities available in the post-attack phase of the world. Once vulnerability was problematized from a systems perspective, event modeling lost its centrality in the models as logistics modeling based on systems analysis gained autonomy in the second generation models. In this respect, the shift from Ready to Risk was one of the major steps towards this architectural transformation of the analytical models. Risk precise function was to analyze vulnerability to nuclear war from a systems perspective. For Risk, vulnerability was not merely a function of the quantities destroyed by the attack. It was a function of the geographical distribution of vulnerable points. While under Ready vulnerability was analyzed through point analysis, for Risk vulnerability had to be calculated at the aggregate level and this aggregate level was not simply the summation of individual vulnerability of points. Hence, one could reduce the vulnerability of a given set of targets by merely alternating the geographical configuration of these targets.

Even though Risk was an important threshold for the conceptualization of vulnerability from a systems perspective, it was still functioning within the logic of event modeling and for this reason logistics analysis was still marginal in this model. This brings us to the significance of PARM, since for the first time logistics analysis gained autonomy under the ethos of preparedness. As Risk and Survival models addressed the problem of survival from damage and supply-requirement's analysis perspectives, PARM's role was planning for recovery problems of an entire economy after an attack. Recovery became an important concern from the perspective of emergency preparedness for nuclear war, since rapid recovery was fundamental to mobilization for a response back to the surprise Soviet attack. Any obstacle to recovery came to be seen as vulnerability itself.

In PARM, vulnerability came to be located at the level of activities, since the model's primary object analysis was interaction of dynamic and interdependent activities. While "in the short term and primarily local analysis of supply-requirement balances for individual survival items, it was not necessary to give extensive consideration to the vertical and time-phased constraints that may be imposed upon resources used in production,"[38] recovery problems necessitated longer-term analysis. PARM was not only concerned with survival items, but also with items necessary for operation of the economy. Long term analysis could not ignore interdependencies among industries and total supply-requirement balances.[39] Positive appreciation of vertical and time-phased constraints led to the emergence of tight spots in a given production system. From a systems perspective, these tight spots were identified as vulnerable points, since they limited the productive capacity of a given system to a level that is lower than the optimum level. These vulnerable points were called bottlenecks in logistics modeling, since the rate of flow from a bottle is a function of the neck of the bottle regardless of the shape of the bottom part. Leontief's I/O model was instrumental in the identification of potential vulnerable points in a given economic system as bottlenecks. Even though the only difference in the architecture of PARM from Survival was the insertion of I/O model to demand estimation, this simple addition to the model allowed production to conceptualized from a systems perspective.

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[38] Joseph D. Coker, "The Role of NREC In Emergency Preparedness," in *Bi-Regional Meeting of Manpower Mobilization Coordinators* (New Orleans, Louisiana: 1965), 23.
[39] *Ibid*., 17.

In the second half of the 1960s, with the escalation of Vietnam conflict PARM's potential use in mobilization for limited war became apparent. Under capitalist democracies, mobilization for limited war faced the obstacle of autonomous economy. Mobilization had to be done in a way that will not affect the markets, since the autonomy of the markets could be easily undermined by the enormous state demand. Strength model, one of the successors of PARM, was developed towards this end. "The first, and most obvious, use of the Strength model," stated the NREC report in 1966, "will be to estimate the impact of various intensities of limited war upon major sectors of the economy, and to compare these requirements with the capacities of the major sectors of the economy in order to identify potential shortages and areas of unused capacity.[40] The report indicated that potential future peacetime use would include "effects of proposed changes in national policy and programs such as withdrawal from Southeast Asia, disarmament, major changes in space programs or highway programs, major changes in international trade policy [and] major changes in tax policy."

One of the major peacetime applications of Strength turned out to be a very unexpected one. Under the Nixon administration, OEP found itself to be the administrator of Wage-Price Freeze anti-inflationary program. OEP is said to be the institution with the most adequate capabilities for such a task. The link between Strength and Freeze is a minor model that was developed towards the end of 60s. Stable Produced Input Model (SPIM) marked the shift from the problem of supply-demand relations to that of price. SPIM combined I/O modeling with regression models to predict future price.[41] Even though Peskin, the developer of SPIM, left OEP before OEP's involvement with Freeze,

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[40] "National Resource Evaluation Center," p. 4 in attachment C.
[41] By H. M. Peskin, "SPIM: An Inter-Industry Price Determination Model ".

SPIM marked the construction of the second pole of the classificatory space upon which the concept of emergency operates.

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