A CYBERNETIC APPROACH TO HURRICANE HAZARD MANAGEMENT ON O'AHU, HAWAI'I

Anja Christina Reissberg
Hafenstr. 12
CH – 9323 Steinach

ABSTRACT

This dissertation was set out to reveal deficiencies in hurricane hazard management on the island of O'ahu, Hawai'i. The hurricane risk for a strong hit or near miss on O'ahu lies at about 1-3%. This probability seems low, but risk is mathematically constituted by the probability of an event times the magnitude of the consequences of the event. Consequently, the severity of the impacts needs to be considered. As the vulnerability analysis showed, those impacts would be catastrophic.

Compared to the damage extent of Hurricane Katrina still vivid in the memories of many, O'ahu faces a much more vulnerable situation due to its isolation, high population density and fragile infrastructure. In human terms, the biggest difference is the infeasibility of evacuation of the island's population of almost one mio. people, which would be highly vulnerable due to the failure of 80% of the island's infrastructure. Honolulu International Airport would be unavailable for an extended time and the extensive damage to harbor facilities and smaller inland airports would limit the island's resource access to a great extent. Overall, all critical infrastructure including energy, transportation, communications, food, sanitation and water distribution and emergency services would be severely impacted. Given the picture of great potential problems, there is a need for a way to maintain a society's internal stability and reduce the vulnerability in face of such an external threat. Cybernetics in general and the VSM in particular, seemed to offer potential solutions.

The objectives of this dissertation were (1) to investigate if hurricane hazard management in Hawai'i can be improved by the VSM looking both at the structure and the processes; and (2) to evaluate the VSM's applicability to disaster management and the insights for Geography and hazard management research.

The VSM revealed that all system elements were in place, but the balance, quality and importance of some need urgent adjustments. A major structural drawback was the hierarchical structure of the National Incident Management System, even though it had cybernetically sound aspects such as a redundant system structure and a maximum of seven System 1 elements. System 2 was evident on paper, but overall it was an unpracticed system element. System 3* (audits) was failing through all Levels of Recursion. System 4 (intelligence) was evolving, but very weak at the time of investigation. System 5 (policy) was strong given the subject matter.

Overall, the application of the VSM to hurricane hazard management confirmed the model's usefulness. It is specifically capable of dealing adequately with the discontinuous temporal character of a 'hibernating' system such as a disaster organization. Besides application problems such as the abstractness of its language and concepts, it was concluded that after the big effort in the beginning shortens with more experience, the model reveals its excellent diagnostic capabilities. The VSM is analogous to a treasure map: You can run around an island and find the treasure by chance. This way, one can know about the treasure, but take forever to find it. The VSM, in contrary, leads you right to it. The insights could maybe be found out without the VSM, but it would take a longer time to reach those insights, one would need a variety of other approaches to do so and therefore need a variety of experts that speak the same meta-language. This is the great advantage of a VSM application: it can integrate different fields of knowledge and fits therefore into the field of Geography. It is capable to grasps the full complexity of the very interdisciplinary field of disaster management. This shows why the cybernetic meta-language and abstract concepts are necessary, highly useful and worth learning.

Keywords: disaster management, management cybernetics, hurricanes, O'ahu

A CYBERNETIC APPROACH TO HURRICANE HAZARD MANAGEMENT ON O'AHU, HAWAI'I

Problem Statement

Natural disasters seem to be on the rise worldwide and their increasing frequency and dimension [Munich Re Group, 2004] make them more and more the focus of society's concern. But do natural disasters really occur more often than before? Are they more disastrous because of their physical manner or because they are socially constructed, with society increasingly 'getting in nature's way'? The latter appears to be the case. For example, globalization has led to more direct linkages of distant places than existed in the past. The rising interconnectedness and dependency of elements within human systems increase this complexity while the nature of those connections gets more complicated and the number of system elements increases. Factors such as population growth, agglomeration of population and capital value in metropolitan areas, rising living standards, settlement and industrialization of very exposed areas, vulnerability of certain elements and groups in modern society, and the increasing number of high-risk technologies, all play a role [Munich Re Group, 2004]. Further, an increasing complexity of infrastructure, especially communication systems, makes human society more vulnerable to natural hazards. Trust and dependency on information technology, in particular, enhances vulnerability even more. Environmental degradation, such as surface sealing, global warming and climate change, are other dynamic pressures on the stability of human systems. Consequently, the effects of events like natural disasters are felt more quickly. A more effective response is needed in order to address these many negative impacts.

In the Pacific, small island states are especially vulnerable to hurricanes ('typhoons', 'cyclones') due to their small size, isolation, fragile ecological systems, poorly developed infrastructure, limited fresh-water and other natural resources, fragile economies, limited financial and human resources and low elevation above sea level. Among these islands, the Hawai'ian Islands have the highest population density of them all [Pacific Regional Environment Program, 2003]. Urbanization has increased the concentration of people and capital in Hawai'i's coastal areas, especially on O'ahu. A direct hit on O'ahu by a hurricane would put in jeopardy a significant portion of its population and economic wealth.

'Hurricane threats will be frequent and actual strikes will be rare' (see Figure 1 [Businger, 1998][University of Hawai'i, 1993, pp.2] and the Appendix of the full dissertation for more detail).

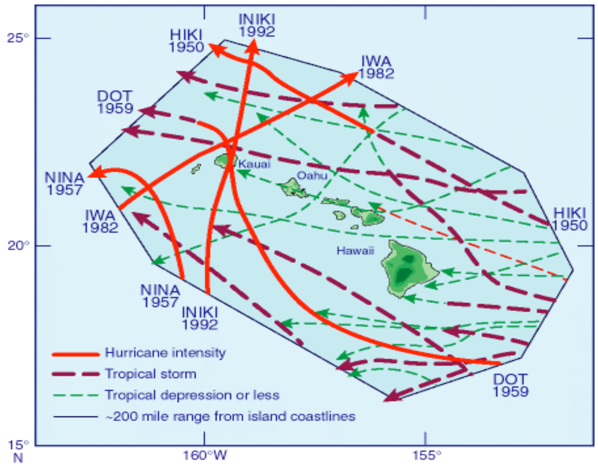

Figure 1: Diagram capturing all tracks of tropical cyclones passing within 3 degree Latitude of the islands between 1950 and 1992. Major hurricanes are named.

But, hurricanes are by far the most costly disasters in Hawai'i (see Table 1).

Table 1: The most costly disasters in Hawai'i

HAWAI'I'S COSTLIEST NATURAL DISASTERS

A preliminary damage estimate of $80 million from the Oct. 30 flooding in Mānoa Valley would make it the fourth-costliest natural disaster in Hawai'i history. Here's a list of the state's worst:

1. Hurricane 'Iniki	Sept. 11, 1992	$2.6B, 4 dead
2. Hurricane 'Iwa	Nov. 23, 1982	$307M, 3 dead
3. Big Island flood	Nov. 1, 2000	$88.2M
4. Floods	Jan. 6-14, 1980	$42.5M
5. New Year's flood	Dec. 31, 1987	$35M
6. Tsunami	May 22, 1960	$26.5M, 61 dead
7. Tsunami	April 1, 1946	$26M, 159 dead
8. Kilauea Lava Flow	1990	$21M
9. Floods	March 19-23, 1991	$10M to $15M
10. O'ahu flood	Nov. 7, 1996	$11M

Source: Hawai'i Civil Defense

In theory, the hurricane risk for a strong hit or near miss on O'ahu lies at about 1-3%. This probability seems low, but risk is mathematically constituted by the probability of an event times the magnitude of the consequences of the event. Consequently, the severity of the impacts needs to be considered. As the vulnerability analysis shows those impacts would be catastrophic.

Hawai‘i’s isolation makes outside assistance very difficult to provide - the neighbor islands, the west coast of the United States, and Guam are the nearest responders. Transportation of resources by air or sea takes on average five hours or several days, respectively, coming from the west coast of the United States or Guam. Infrastructure damage to the islands will limit the functionality of those life-sustaining transportation corridors. O’ahu support infrastructure faces catastrophic inundation and damage, especially the harbor and airport facilities and also the main power production facilities (both electric generation and liquid fuels). O’ahu’s vulnerability is enhanced by its high population density and the fact that 80% of Hawai‘i’s population live on O’ahu, which makes the population especially vulnerable due to limited fresh-water and other resources. O’ahu is highly dependent on imports and other islands cannot assist O’ahu because they themselves are dependent on O’ahu for energy, food and other commodities. O’ahu’s economy is very fragile because it is highly dependent on tourism that would suffer substantially from a catastrophic hurricane event. Further, no transportation for evacuation is available or feasible, both for the local population or tourists. A comprehensive vulnerability analysis is provided in the Appendix of the dissertation including the damage scenarios and assessments of the Hawai‘i State Civil Defense and the Federal Emergency Management Agency.

In response to these vulnerabilities, an effective disaster-management system must be based on the fact that the nearest responders are the State’s least damaged islands. Except for the limited assistance that the least damaged islands might provide, Hawai‘i State Civil Defense estimates that the population of the Hawai‘ian Islands will be without outside assistance for at least one week after a major hurricane event [Teixeira, 2007]. Focusing on O’ahu, Ed Teixeira, Deputy Director of Hawai‘i State Civil Defense, has observed that planning for a high-impact-low-probability event like Hurricane Katrina on O’ahu has not much evolved: ‘because it was unthinkable and too hard to think about’ [Teixeira, 2007b].

Given the picture of great potential problems, there is a need for a way to maintain a society’s internal stability and reduce the vulnerability in face of such an external threat. Since the risks and damage potential of natural events cannot be changed or managed, it is crucial that specifically human-caused vulnerabilities be kept to a minimum. One way to achieve this is through an effective and efficient disaster management system, which this dissertation aims to explicate. Cybernetics in general and the Viable System Model in particular, seemed to offer potential solutions.

Objectives

The objectives were (1) to investigate if hurricane hazard management in Hawai‘i can be improved by the Viable System Model (VSM) looking both at the current disaster management structure and the processes on O’ahu; and (2) to evaluate the VSM’s applicability to disaster management and the insights for Geography and hazard management research.

Choosing the Viable System Model

Management cybernetics was chosen because much of geography and hazard management research only describes what goes wrong during hazards. Some approaches offer explanations for damages, such as people’s poor perception of the phenomena and poor choices of response, the nature of the geophysical phenomena themselves or the nature of institutions that create or exacerbate risk and vulnerability for society or particular groups within it. Geography rarely addressed how to improve hazard management in general and in an proactive stance. Further, the VSM was never applied to disaster management.

Another reason to choose the VSM is given because it deals with messes – not defined problems - and can illuminate why things go wrong. Its theory says that the sum of the elements is greater than the sum of its parts. Instead of examining the cause and effect in a linear manner, the VSM specifically looks at the links that hold the system together in a holistic manner and therefore takes a system's full complexity into account. Since disaster management is highly complex field, the VSM is very applicable since it can integrate quantitative and qualitative measures, it can provide a common language and framework to discuss the management support and coordination needed by the groups working in the field of disaster management – private and governmental agencies, non-governmental and volunteer organizations. The VSM can further support such research since it can incorporate different disciplines without having its basic structure and dynamics obfuscated and it can diagnose hibernating and temporary systems that jump in and out of existence. From a practical standpoint, the federal disaster management system is constituted by the Federal Emergency Management Agency's (FEMA) Incident Command System (ICS), which is a systems approach. So it is both inviting and highly useful to diagnose this system with a similar approach coming from the same field of thinking. Overall, the VSM seemed to have great potential to improve the effectiveness of hurricane hazard management.

The Theory of the Viable System Model

Cybernetics as the science of communication and control in the animal and the machine was applied to management by Beer, who named it then science of effective organization. The main concept of the VSM is viability, which is the ability to maintain a separate existence within a turbulent environment. The VSM demonstrates how complex systems maintain internal stability in the case of external disturbance, such as a hurricane event. The aim of the VSM is not single-goal oriented, e.g. maximizing profits, but viability and survival. In essence, the VSM emphasizes the means for survival. Its concepts and language are hard to understand because they are abstract, but this way it can be integrative and also holistic, which applies highly to Geography. System 1 stands for implementation, System 2 for coordination, System 3 for control, System 3* for audits, System 4 for intelligence, System 5 for policy and the environment constitutes not only the natural environment, but all that is outside of the System as a whole. Overall, the VSM does not offer a normative model, but is a diagnostic tool and it requires working with people from within the System using their subjective input.

Another important concept is Variety, which is the number of distinguishable states of a system and a measure of complexity. The environment is bombarding the coping system with threats, stresses, pressures and the art of managing all of this is called Variety Engineering. Further, recursive structures are central to understanding the VSM. It says that every viable system entails and is entailed in a viable system, like Russian Dolls. This concept is needed to handle variety and complexity through redundancy. This enables one to investigate a problem of natural and human systems as one complex system of interactions on different Levels of Recursions.

The data collection

The Hurricane Hazard Management System (HHMS) is constituted by all entities involved in hurricane hazard management for a catastrophic hurricane on O'ahu and entails the full disaster cycle from mitigation to recovery. It involves the Federal Emergency Management Agency (FEMA), which developed the Concept of Operations (CONOP) for a catastrophic hurricane impacting the State of Hawaiʻi that includes all governmental departments and agencies, the National Incident Management System (NIMS) and the National Response Plan (NRP). It involves further a plethora of non-governmental organizations, e.g. American Red Cross and the private industry, e.g. the Hawaiʻian Electric Company. The data collection included conferences, presentations, interviews, email contacts, observations, mainly the State Civil Defense's Makani Pahili Exercise, FEMA's Region IX Regional Interagency Steering Committee Conference and the State Civil Defense's Debris Management Seminar. Further, books, grey literature, reports, websites were researched.

The application of the Viable System Model

In the beginning, the VSM leads you to choose a System in Focus and then investigate one or two Levels of Recursion up or down from there (Table 2). The System in Focus was chosen to be the Joint Field Office (JFO) and its organizational structure, the Incident Command System (ICS). As shown in Table 2, the Level of Recursion 1 regarded the NIMS framework including all Emergency Operation Centers (EOC) and Incident Command Posts (ICPs). Level of Recursion 3 was constituted by the Emergency Support Functions (ESFs) and Level of Recursion 4 involved all departments and agencies filling the ESFs.

Table 2: Matching all HHMS levels with the VSM Levels of Recursion under aspects of time

HHMS levels	Level of Recursion	Time of existence	Diagnosis
One department or agency	LoR 4	continuous	mentioned
Emergency Support Functions (ESF)	LoR 3	continuous	included in diagnosis
Incident Command Structure (ICS): IC plus Sections	LoR 2	hibernating	System in Focus
NIMS framework: EOCs, ICPs	LoR 1	hibernating	included in diagnosis

The Hurricane Hazard Management System's (HHMS) measurement system of viability was clarified first. The timeline of the measurement system is the annual cycle of the hurricane season. The federal 'measurement' system is constituted by the Homeland Security Exercise and Evaluation Program (HSEEP) and on the state level, the State Civil Defense executes the annual hurricane exercise called 'Makani Pahili'.

The Cybernetic measurement system involves the indicators of effectiveness and performance measures. Those express the likelihood that something goes wrong and are taken constantly. The VSM designs this measurement system with parameters subjectively chosen by actors within the HHMS. Variables to measure are e.g. the resource status, the change of employees, morale or knowledge. If certain pre-set values are exceeded, a red flag will alarm the system and induce action to proactively prevent the failure of the disaster management system as a whole. Overall, one red flag would not matter to the system, but many small ones can. Those red flags are called 'Algedonic Alarms' because one needs to be aware that those alarms are not used in everyday language and are not caused by an approaching hurricane or some related threat. These Algedonic Alarms sound due to ineffective or dysfunctional elements within the HHMS and are preemptive signals about dysfunctions. They have to be in real-time because managers must be alert to instability in real-time. For example, the testing of the emergency generators, usually lasting for half an hour, does not proof that the system it supports will run for the necessary amount of time in a disaster. Ultimately, the requirement for viability is that the Algedonic Alarms have to be fixed within the relaxation time for the HHMS to remain viable. For example, the relaxation time for Level of Recursion 1 is the annual cycle along the mentioned exercises, for Level of Recursion 3 could be the training status, measured monthly and set subjectively. For the HHMS, a constant alarm signal would sound and would be loud. The HHMS in its current status is certainly not viable, due to its many deficiencies.

Diagnosing the structure – the static Hurricane Hazard Management System

First, the static Hurricane Hazard Management System (HHMS) was investigated along its structure, followed by the diagnosis of the HHMS processes. The structural diagnosis through the VSM was accomplished in two parts: (1) the NIMS framework prescribed by FEMA gave an overview of the HHMS structure as a whole and showed how all elements are plugged in together, constituting dimension 1 and 2; and (2) the O'ahu Joint Field Office (JFO), the federal Emergency Operations Center, was diagnosed in detail with the Incident Command Structure (ICS) as the federal template structure for disaster management (dimension 3). This way, a thorough analysis of the HHMS along three dimensions was accomplished (Figure 2): Horizontally along the geographical division of the various Incident Command Posts as prescribed by NIMS (1), and vertically along the functional ICS (2), which is the basic structure for all Command Posts. The Emergency Support Functions (ESFs) in the diagram will be elaborated later and will add another layer (dimension 4).

Overall, a major structural drawback was evident because the VSM requires a non-hierarchical structure, but the National Incident Management System (NIMS) elements are hierarchical. There's a managerial hierarchy in an enterprise, but the higher levels are characterized by its order of perception and language in logic, not by its capacity to command. In disaster response, when quick action is necessary, waiting for authorizations to be approved can be costly in terms of damage to both victims and the reputation of the responders. The hierarchical setup is cybernetically wrong. In sum, the

VSM revealed that all system elements are in place, but the balance, quality and importance of some need adjustments. This can be exemplified on Level of Recursion 3 (see Table 2).

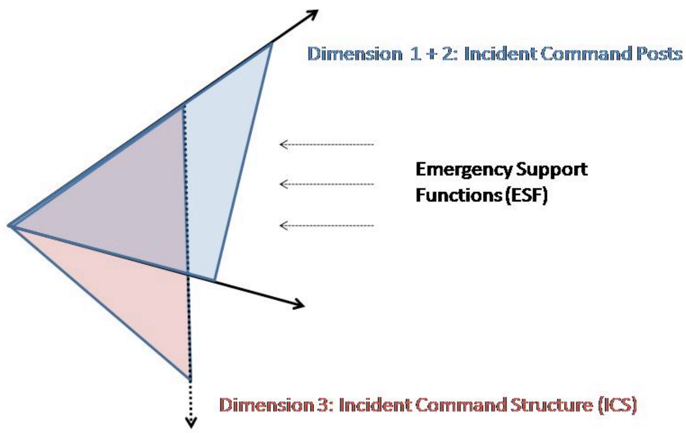

Figure 2: The four dimensions of the Hurricane Hazard Management System

The Federal Emergency Management Agency (FEMA) represents System 5 (policy), the State Civil Defense and the county Department of Emergency Management represents System 3 (operational control) and 4 (intelligence). System 2 (coordination) is defined by the National Incident Management System (NIMS) and the National Response Plan (NRP). In Figure 3, the deficiencies on Level of Recursion 3 are shown.

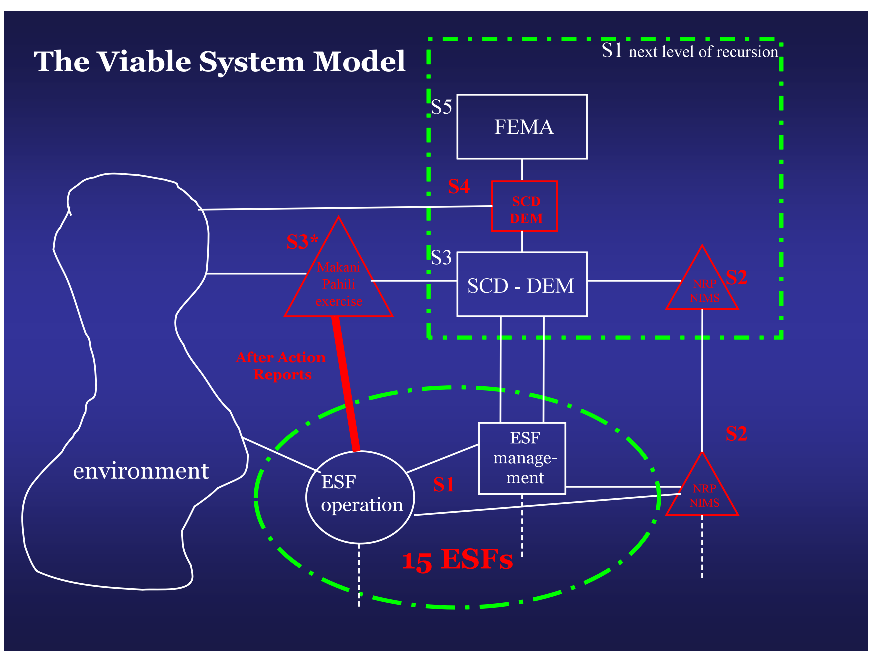

Figure 3: Deficiencies revealed on Level of Recursion 3

System 1 (implementation) has 15 ESFs instead of a maximum of 8 elements prescribed by the VSM. Stafford's recommendation of six to eight System 1s (implementation) was based on G.A. Miller's famous 1956 paper 'the magic number 7 + or – 2' [Miller, 1956]. This represents the level of differentiation the human brain can easily accommodate without additional patterns. The paper summarizes research on light levels (visual), sound levels (auditory), sweetness, sourness, taste, among others and is the basis for the choice of seven digits for phone numbers. In that case, the VSM suggests inserting another Level of Recursion to summarize those activities (ESFs). Another major deficiency is evident because System 2 (coordination) exists only on paper, but is not implemented. As a consequence, HHMS personnel think that they have a system to use in an emergency, but its application is not exercised or even planned for. Therefore, HHMS personnel have a false sense of security, and in catastrophic event, they do not know their roles and responsibilities. A major deficiency is further that no Incident Command System (ICS) application for a catastrophic event is elaborated on the local level and that decisions would be made on a case-by-case basis, a major System 2 (coordination) and System 4 (intelligence) deficiency.

Figure 4: Honolulu International Airport scenario

Additionally, inconsistencies regarding FEMA's Concept of Operations' (CONOP) assumptions and its planning exist, also a System 2 (coordination) implementation failure. For example, a major misjudgment regards Honolulu International Airport (see Figure 4)[US Army Corps of Engineers, 2007]. At the FEMA conference, it was assumed that Honolulu International airport could be used, but the US Army Corps of Engineers showed an airport scenario from before and after the landfall of a catastrophic hurricane at the Debris Management Seminar, which made clear that its usage would be impossible. Consequently, how can you effectively plan, if some HHMS key personnel assume that Honolulu International airport is available if it will be impossible?

Another problematic issue is the geographic differentiation of O'ahu. The county level Department of Emergency Management divides O'ahu into six districts, FEMA divides O'ahu into eight districts, based on census districts, and for debris management O'ahu showed four divisions. Effective planning is made impossible, which consequently is evident for all Levels of Recursion. Another issue is the inconsistency regarding damage assessments, where different organizations involved – the State Civil Defense, the Department of Emergency Management, the American Red Cross – use different assessment tools and language. Overall, the VSM shows that effective disaster management is not necessarily a problem of resource constraints, e.g. funding, and that there is room to improve efficiency in different ways.

Furthermore, System 4 (intelligence) has too little emphasis. More long-term planning would be necessary that involves all ESFs while being aware of their capabilities to create synergies between them. Regarding System 3* (audits), a major deficiency shown by the VSM is that the After Action Reports after the Makani Pahili exercise are accomplished internally, and that there is no external evaluation. This is not sufficient in terms of quantitative or qualitative audit needs because in this situation, only the 'positive' side is highlighted. It is the HHMS department's or agency's decision what to report, what conclusions are drawn, what actions are necessary and implemented. No control mechanism exists from FEMA, State Civil Defense or the Department of Emergency Management to ensure that those reports are accurate and therefore effective. That also means that System 1 (implementation) autonomy is too high and system cohesion is lost. The VSM pronounces the importance of those factors for the overall system efficiency. Otherwise, these 'minor' problems might not be fixed or its heavy systemic impact underestimated.

Diagnosing processes – dynamics of the Hurricane Hazard Management System

The main concepts of system processes are the Resource Bargain, the Accountability Loop, Channel Capacity and Transduction. As an overview, each concept will be treated here shortly.

Looking at the Resource Bargain, the System 3-1 interaction, a known problem is the underfunding of the Hurricane Hazard Management System's (HHMS) departments and agencies. In terms of variety, that means that System 3 (operational control) is overwhelmed by System 1 (implementation) resource requests. For example, if animal shelters are taken into account, environmental variety is amplified, but one needs to ask what can be done with given resources. Ashby's lay says that a governor can only control with what he has available and that the variety of a governor is limited. And further, System 5's (policy) identity must be pursued by System 3 (operational control), which will constrain System 1 (implementation) autonomy regarding their wishes and needs, for example if they go greedy. Of course, even with a perfect cybernetic structure, without resources to plug into this structure the system will fail. The State Civil Defense cannot help the Honolulu Police Department if it does not exist, as happened in New Orleans. We know, resource constraints exist, but there are other constraints regarding resource allocation and logistics that could alleviate the problem of lack of resources. In the United

States, there are enough resources, but it is a matter of system effectiveness rather than resource constraints if resources are in place when and where they are needed.
Regarding the Accountability Loop, no evaluation or check if the resources are used efficiently or no coherent reports exist, a System 3* (audits) failure. Inefficiency persists due to excessive System 1 (implementation) autonomy and a lack of System 2 (coordination) implementation. Channel Capacity, the measure of the amount of information transmitted in time *X,* is insufficient due to the System 2 (coordination) failure: information cannot flow where language or concepts are not understood. This problem exists on all channels. Transduction, the mechanism for information crossing boundaries from one component to another (e.g. military-government) and for accepting input in one language or realm of reference, and send it on in another, suffers also from the missing System 2 (coordination) implementation. It shows up, for example, regarding the interoperability of communication systems, the language differences between the military and the government, and also regarding the command-and-control versus the democratic structure. Further, it is Transduction where soft factors come into play: power, conflict, personal skills and assets, the cultural identity in Hawai‘i or stress and frustration. The VSM recognizes their importance and influence regarding the viability of the system and its effectiveness. Ultimately, the information flow depends on them. Ultimately, in a situation of a catastrophic hurricane on O’ahu, we have a Variety explosion within the Environment. For the HHMS, that means it has to counterbalance that Variety. In general, disasters generate a sudden data overload for those who want to manage in them. Finding out how the actors in the system are coping with that overload is a way to understand their way of Variety Engineering. Many examples were given throughout the dissertation.

Lessons of the Viable System Model application to hurricane hazard management

Recalling the objectives of this research, the lessons can be organized in 3 rubrics: the advantages and drawbacks of the VSM, insights for the field of Geography and insights for hazard management research.

Critique of the Viable System Model

On the positive side, the VSM is a bonified methodology, but it is a craft, that requires practice. Beer used the VSM in consultancies for four decades and demonstrated increases in efficiency of between 30% and 60% [Walker, 2001]. It is not only explanatory as a diagnostic tool, but sets up a real-time measurement system and therefore is proactive. In sum, the VSM does not offer a quick fix or promises to solve specific problems, but it shows why things go wrong and it deals with messes. It is a fine-tuning tool that can point out the improvement potentials of a system. Instead of prescribing drastic actions to be instantly taken, which would destabilize the system, the VSM suggests a continuous cybernetic process to promote viability. It needs to be accepted that the implementation of the cybernetic process to evolve to a viable system takes time. The VSM seeks true coping ability and demands to be proactive and prepared. In addition, it is expandable with other models.

The VSM is unique because it shows how to increase efficiency with given resource constraints, as was shown regarding the System 2 (coordination)-related inconsistencies. It shows that a well-designed information system can be used as an alternative to authoritarian control. The VSM highlights the balance between autonomy and control, managing present and future activities, and makes clear distinctions between different management functions, so that people in organizations can be conscious of what the context of their decision making is. For example, the VSM can clarify if it is an issue about (S5) identity or values; or about (S4) potential actions or preparations; about (S3) the 'here and now' necessary choices; about (S3*) detailed investigation of a specific area of operations; or about (S1) decisions about interactions with the Environment.

Further, the VSM distinguishes seven different channels of communication. It highlights the importance of certain functions and processes that otherwise would not get much attention, e.g. the missing external check on After Action Reports or the missing checks on ICS implementation and it highlights the need for real-time data, a factor which is often disregarded. The VSM makes gaps in information flow visible: A lot of knowledge is available locally, but there is no requirement or incentive to share this information. The VSM is comprehensive because it is very abstract using a cybernetic Meta-language, but therefore it can entail many other approaches.

The VSM enables us to make diagnoses and distinctions more effectively by carving out a particular operational domain from the 'messiness' that is reality, and to look at that carved-out bit according to certain explicit rules and conventions. For example, one FEMA representative stated that emergency management in the USA is a system of sequential failure. After each level of government fails, the next level steps in from the county level to the State level to the Federal level. Instead of sequential failure, the VSM would call for proactive action that is necessary to enhance systemic effectiveness, e.g. FEMA resources should be in the field earlier, before failure occurs [Fenton, 2007]. To achieve this proactive perspective, the VSM argues that a system failure does not stem from cause-and-effect relations, but from the pathology of the system as a whole. A cybernetic approach aims at designing an effective system beforehand.

The VSM is, therefore, an integrative tool based on the natural laws and hard science underpinning control engineering, while simultaneously accommodating soft factors. The fact that it is rooted in the functionalist paradigm yet exhibits flexibility toward the interpretative realm is one of its great merits. It thus overcomes a major deficiency marking many purported 'systems approaches', in particular the Incident Command System (ICS). Even though a system might have all the necessary elements from a functionalist perspective, this might not be sufficient for the system to run efficiently and effectively from an interpretative standpoint. Ultimately, social elements determine how the system is executed. For example, social factors such as trust, leadership, authority and credentials challenge any functionalist approach. Taking these factors into account constitutes the essence of VSM, as Beer says, 'the heart of an enterprise is its people' [Beer, 1994a, p.576].

Another VSM advantage is in being reality-based, flexible, and robust. The VSM is reality-based in that it highlights the need for real-time data, a factor which is often disregarded. The need for real-time data leads to the important point that management is a continuing, infinite process. VSM's flexibility allows for inserting elements into a particular Level or Recursion without making dramatic changes to surrounding structures. Its robustness is achieved through a:

'Long-term focus rooted in the identity of the enterprise, and integrated structures evolve over time instead of radical discontinuous change. In many enterprises, radical change through 'restructuring' processes, for example, causes oscillations and damages longer term effectiveness as structures, systems and human relationships are disregarded' [Espejo and Gill, 1997, p.6].

Overall, the VSM is certainly useful for diagnosing problems in and prescribing solutions for system improvement. It is also capable of dealing adequately with the discontinuous temporal character of a 'hibernating' system such as a disaster organization. On the other hand, it is impractical in a variety of ways and the drawback to VSM application is discussed next.

First of all, its language is too specialized to be learned easily, its concepts too abstract to be easily adopted, and, most important, it is not intuitive in situations where politics is 90% of the game and expertise 10%, where the real decision-makers have other priorities and interests, for example, getting re-elected. Further, it takes several years to apply the VSM to a super-organization such as a HHMS. During that process, the turn-over of staff will itself become a problem [Beer, 1989b]. Those are major drawbacks to VSM application.

Paradoxically, one of the greatest strengths and weaknesses of Beer's VSM is that it does not provide clear prescriptions, but rather explains why things do not work – a critical but not necessarily constructive outlook. The 'prescription' the VSM delivers is the abstract model of the Viable System itself, and the elaboration of this abstract model is subjective. For, Beer as a research philosopher states that scientific neutrality is impossible [Beer, 1981]. Consequently, there is no normative model of the Hurricane Hazard Management System (HHMS) or of any other system to be diagnosed from a VSM perspective. And, the quality of the diagnosis depends completely on the capabilities of the cybernetician who is dependent on the system's actors – on their subjective understanding, their willingness and Capability to communicate their understanding of the system to the cybernetician. But, if the VSM offers no prescription in the traditional sense, it is an explanatory or diagnostic tool. Beer emphasizes all through his research that VSM does not solve specific problems, but is a fine-tuning tool par excellence that can point out the improvement potentials of a system in focus.

The metaphorical, or paradoxical, quality of VSM is seen particularly in that the free information flow within the HHMS is not realizable. In part, this is due to competition between the private companies involved, e.g. telecom companies, and disaster managers. In part, and more important, some aspects of the human condition are just not computable, which greatly frustrates real-time data collection. For example, within the HHMS, it is assumed that its personnel are honest at all times, which is quite unrealistic. Other incomputable factors are the number of absent days of employees, or the quality of their relationships. Both factors lead to an incomplete real-time information system within the HHMS. But a complete real-time information system with free information flow is required in the VSM. Paradoxically then, the VSM explicitly limits the scope of its claims about the quality of humanity and human individuality. The VSM acknowledges that human Variety always remains a Black Box and is in some way or another ineffable. 'The basic element from a systemic point of view is a system of relations between people knowing each other and dealing with each other in interdependent activities and creating their meaning out of the interaction between the work they do and their relations' [Harnden, 2006]. Again, paradoxically, because it is basically a metaphor, the VSM has no ability to address the complexity of human behaviour in practice, e.g. personnel fluctuation within the VSM, or people having their own self-interests and the human mess cannot be considered fully by the VSM because it is too dynamic. But this is not what the VSM is trying to achieve. It is exactly that 'redundant untidiness of the human condition that leads to the ability of a complex system to be viable' [Beer, 1994a, p.326]. A system's stability is reached exactly because of this unseizable complexity. Therefore, the VSM is both paradoxical and an excellent metaphor.

Ultimately, Beer believes strongly that 'it is both silly and agonizing to reach successful organizational outcomes by trial and error, if the rules of the game are already known' [Beer, 1989b, p.212]. Beer believed that mathematics, and by extension models based on them, are either tautological or wrong. The VSM is a pragmatic explanation and is not right or wrong, or tautological or consequential, but more or less useful – parallel to Wilson's definition of a model that requires above all its usefulness [Wilson, 1990].

Beer emphasizes that manager and cybernetician need to work hand in hand [Beer, 1989b]. What is crucial in consulting is the model-user relationship. The VSM is perfect and tautologous by itself, but the capability of the user to apply the model causes the problems. Consequently, the focus should be on the user, on the individual, who is the ultimate Recursion of the system. Therefore, Beer called himself a Guide, Philosopher and Friend pronouncing the importance of personal relationships in this consulting process of VSM application, as he said, 'there had to be long and detailed discussions about the mode and its diagnoses' [Beer, 1989b, p.248]. The VSM application requires from the HHMS people their willingness, intellectual capability and a profound understanding on top of fulfilling their regular job.

An overall question is if the VSM is practical. This research came to the conclusion that after the big effort in the beginning shortens with more experience, the insights are highly useful. In sum, the VSM can be seen as a treasure map: You can run around an island and find the treasure by chance. This way, one can know about the treasure, but take forever to find it. The VSM, in contrary, leads you right to it. The insights could maybe be found out without the VSM, but it would take a longer time to reach those insights. Plus, one would need a variety of other approaches to do so and therefore need a variety of experts that speak the same meta-language. This is the great advantage of a VSM application: it can integrate different fields of knowledge and therefore fits into the field of Geography. Therefore, the cybernetic meta-language is necessary, highly useful and worth learning. Overall, the VSM is a check that all issues are covered.

Insights for the field of Geography and hazard management research

The field of Geography is very fragmented and involves a wide range of fields in both the physical and social sciences. That these fields do not necessarily communicate fruitfully with each other is well known. The VSM emphasizes the validity of both. The VSM is an integrative tool because it is based on natural laws and hard science that underpins control engineering, but it also accommodates soft factors. One of its great merits is that it is rooted in the functionalist paradigm but exhibits flexibility toward the interpretative realm. Therefore, it has the capability to integrate the soft and hard sciences.

Specifically because the field of Geography is so fragmented, natural hazard and disaster research today has no separate identity. The problems concern – besides the fragmentation of the field – the disciplinary boundaries and over-specialization, which lead to a slowdown in progress. Lack of power, lack of funds and the fear of identity loss of involved fields worsen the situation for both Geography and hazard research. The debate about scientific truth, the validity and reliability of terminologies keep many research efforts and successes in further distance, unfortunately. The VSM could be one model that shows how those fields can work together and be integrated in a most useful and synergetic way.

Advancing both fields, one of the VSM's merits is to provide a 'framework for viability to inject cybernetic language into discussions that usually involve conflict of personalities and apportioning of personal power' [Beer, 1989a, p.235], factors that the rational actor paradigm does not deal with adequately. Conflict stems from differences in values, knowledge, *Weltanschauungen* and personalities. The VSM recognizes that power relations need to be considered, as well as trust, solidarity, stakeholder involvement and participation. In general, these subjective social concerns are often underrepresented in disaster management decisions, since short-term thinking governs politics and long-term disaster mitigation measures fall behind popular policy measures. Beer invented Syntegrity for the purposes of free information flow within a complex social system that is highly interconnected within and to an outside environment [Beer, 1994b].

The systems approach is valuable since it pronounces the connectivity within. It postulates that the whole is more than the sum of its parts – as opposed to reductionism. Even if a single or several units suffer a total breakdown, the system as a whole can still be stable and fix the units under stress. Management cybernetics respects those mentioned viewpoints since it depends on the choice of the System in Focus by the cybernetician and ultimately on the subjectively chosen identity of the system.

In sum, the VSM grasps the full complexity of the field of disaster management, including hibernating systems. It is flexible because it is capable to entail any Level of Recursion, any organization, any disaster type, size of disaster, on any timeline. It emphasizes a proactive stance by setting up an Algedonic Alarm system that informs the manager of any incipient instabilities within the system he manages. Therefore, one focus lies on reducing vulnerabilities – and therefore fits in today's paradigm in hazard management research. Further, it points out vulnerabilities in all realms: economic, environmental, social and cultural and complements predominant research efforts of Blaikie and Mileti [2004, 1999]. It promotes a non-hierarchical approach and therefore a participatory approach, which is often aimed for in disaster management today. Further, it highlights the non-resource factors instead of arguing that all shortcomings are founded in lack of funding, for example.

The VSM could serve as a framework for improved disaster management efforts, if you put in the time and effort to learn VSM. As Allenna Leonard, Beer's life partner and cybernetician, stated: the VSM finds many interpretations, but only few get its value. The VSM is a vision – if you believe in it, the System will improve.

REFERENCES

Beer, S. (1981). *Brain of the firm*. 2nd edition. John Wiley, London and New York.

Beer, S. (1989a). The Viable System Model: its provenance, development, methodology and pathology. In: *The Viable Systems Model: Interpretations and Applications of Stafford Beer's VSM*. (R. Espejo and R. Harnden, eds.), John Wiley, New York.

Beer, S. (1989b). The evolution of a management cybernetics process. In: *The Viable Systems Model: Interpretations and Applications of Stafford Beer's VSM*. (R. Espejo and R. Harnden, eds.), John Wiley, New York.

Beer, S. (1994a). *The Heart of Enterprise*. John Wiley, London and New York.

Beer, S. (1994b). *Beyond Dispute: The Invention of Team Syntegrity*. John Wiley, Chichester.

Blaikie, P., et al. (2004). *At Risk: Natural Hazards, People's Vulnerability and Disasters*. Second edition. Routledge, London.

Businger, S. (1998). Hurricanes in Hawai'i. September 25, 1998. Department of Meteorology, University of Hawai'i. http://www.soest.Hawai'i.edu/MET/Faculty/businger/poster/hurricane; accessed 9/5/2007.

Espejo, R. and Gill, A. (1997). *The Viable System Model as a Framework for Understanding Organizations*. Phrontis Limited and Syncho Limited.

Fenton, R. (2007). Federal Emergency Management Agency Regional Interagency Steering Committees Conference, 'ESF#5, 'Emergency Management', PowerPoint presentation, held at the Waikiki Beach Marriott Hotel, Honolulu, Hawai'i, May 22 2007. Unpublished oral remarks.

Harnden, R. (2006). Email of the Metaphorum listserve of May 26, 2006.

Mileti, D. S. (1999). *Disasters by Design*. Joseph Henry Press, Washington.

Miller, G.A. (1956). The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. *The Psychological Review*, 63:81-97.

Munich Re Group (2004). Natural Catastrophes 2003. Annual Review. *Topics geo2003*. NatCatSERVICE-Info, Munich.

Pacific Regional Environment Program (2003). The natural resources of the Pacific Region: http://www.sprep.org.ws/topic/NatRes.htm; accessed 4/11/2006.

Teixeira, E. (2007). Federal Emergency Management Agency Regional Interagency Steering Committees Conference, held at the Waikiki Beach Marriott Hotel, Honolulu, Hawai'i, May 23 2007. Unpublished oral remarks.

U.S. Army Corps of Engineers (2007). Graphs and maps generated for the Makani Pahili Exercise 2007. U.S. Army Corps of Engineers.

University of Hawai'i at Manoa (1993). Hawai'i coastal hazard mitigation planning project: findings, recommendations, and technical documents. Prepared by the Center for Development Studies, Social Science Research Institute, the University of Hawai'i at Manoa, Honolulu.

Walker, Jon (2001). The Viable Systems Model – a guide for co-operatives and federations. SMSE Strategic Management in the Social Economy training programme. ICOM, CRU, CAG and Jon Walker. Eds., Directorate General XXIII of the Commission of the European Communities.

Wilson, B. (1990). *Concepts, methodologies, and applications*. John Wiley, New York.