The Use of Systemigrams in System Template Development: An Example in Disaster Management

Jamie Mussante, Jaime Frittman & Robert Edson

Applied Systems Thinking Institute, Analytic Services Inc.

2900 S Quincy Street, Suite 800, Arlington, VA 22206

Jamie.Mussante@anser.org, Jaime.Frittman@anser.org, Robert.Edson@anser.org

Abstract

Systemigrams can be used in a variety of ways; this paper uses systemigrams as a tool for system comparison in the disaster management domain. Through comparison, systemigrams are used to evaluate disaster management systems of similar disaster types by enabling analysts to recognize recurring elements, shared problems, and common leverage points across multiple systems. To facilitate this comparison, a generic template in the form of a systemigram was created by comparing the systemigrams of the 2010 earthquakes in Chile and Haiti. The systemigram-based template was then tested by applying it to other disasters which are both similar and dissimilar in type and scale. Successful application of the systemigram template to these disasters offers initial confirmation of the systemigram template's generalization to a variety of disasters. This application also demonstrated the systemigram's utility as a system comparison tool for establishing, predicting, and comparing the success of disaster management systems.

Introduction

Systemigrams are typically used as a communication tool and offer a means to graphically depict a single complex system, problem, or event previously described in text. Systemigrams can be used to tell a story of a whole system or they can be used to focus on individual system components (Boardman & Sauser 2008). In this study, systemigrams are used to recognize patterns[1] of actors, processes, and effects across similar complex system events, which, in turn, allows for the creation of a template.[2]

---

[1] In this paper, patterns are defined as a reliable sample of traits, acts, tendencies or other observable characteristics (Merriam-Webster 2011).

[2] In this paper, templates are defined as something that serves as a model for others to copy (Merriam-Webster 2011). In our case, tentative patterns gathered from limited observations inform creation of a template; repeated template use could facilitate validation of known patterns and could result in the recognition of new ones.

A systemigram-based template is useful for analyzing commonalities and discords between the structures, processes, functions, and components of multiple systems. By applying a common template a variety of information can be determined about an overall system, such as leverage points to induce successes and prevent failures. Once gathered, this information can provide a means for predicting a system's success or failure under similar circumstances. Additionally, template-based systemigrams provide a quick way to gather and organize information and may facilitate identification of new patterns across different systems. Compiling patterns about emergency management systems can assist with future planning and can be utilized to establish best practices so as to promote optimal system design.

Problem Statement

In today's world, systems are becoming ever-more complex. In an environment overloaded with information, identification of relevant system details can be difficult. Focusing specifically on disaster management, and disaster outcomes, history demonstrates that similar disasters repeatedly occur, causing loss of life and extensive damage (United Nations International Strategy for Disaster Reduction 2006), especially in societies that are ill-prepared to handle disasters. If disaster management systems are not changed, disasters will continue to wreak-havoc, destroying societies and putting people's lives at risk.

Ideally, the effects of disaster events can be mitigated, and perhaps prevented, limiting loss of life and destruction. Effectively intervening in disaster management systems will mitigate such negative consequences. Analysts can assist with determining intervention points by establishing means to quickly organize performance-related information in complex disaster situations.

Background and Research Objective

Within six weeks of one another, two separate, severe earthquakes hit Haiti and Chile. The damage and destruction in both countries was widespread; however, the extent of the devastation and the timeliness of the response appeared to vary between the two. Despite the comparable earthquake magnitude, media coverage depicted Chile as fairing far better than Haiti. With this in mind, two systemigrams comparing the disaster management systems in both Haiti and Chile were created. The initial goal was to compare the two systemigrams and determine why one country, Haiti, suffered more than the other country, Chile.

After comparing the systemigrams, it became evident that similar actors and processes were present in both events. Hence a new goal for this research emerged; namely, to demonstrate additional utility of the systemigram in discovering commonalities between related systems. This would allow identification of recurring systems elements, shared problems, and common leverage points across multiple systems. To illustrate the systemigram utility as a comparison tool, we will develop an overall disaster management system template in the form of a systemigram. Furthermore, we will demonstrate the systemigram-based template's application to disasters of varying type and scale.

Methodology

The primary tool utilized in this approach is the systemigram. Systemigrams are used to analyze and compare disaster management systems and to develop a common template applicable to other disaster events. The methodology consists of four steps: literature review and systemigram construction, systemigram analysis and comparison, template generation, and template validation.

Literature Review and Systemigram Construction and Analysis

Literature Review. The 2010 earthquakes in Haiti and Chile were identified as the subject events. A variety of literature pertaining to both earthquakes was reviewed, including government and government organization reports. Information gaps were addressed through the use of open source literature such as media reports. [3]

Systemigram Formation and Restructuring. Using the literature review as a basis, systemigrams were constructed for each of the earthquake events. Initial analysis of the systemigrams allowed for binning of similar items[4], these similar items were formatted into a systemigram-based template. The intent of this initial template was to provide a means for organizing elements of a disaster. Using this template, the initial systemigrams were restructured, so as to have a similar look and feel (such as containment nodes housing similar information categories). With information gathered from the literature review, the restructured systemigrams were further analyzed to determine the success and failure of specific elements. The systemigrams included general event details that, according to the literature, either helped or hindered the response. Reflecting these evaluations, nodes and links were color coded. This process formatted the systemigrams for comparison.

Systemigram Comparison

Haiti Earthquake Sytemigram. A systemigram depicting disaster management in response to the January 12, 2010 earthquake in Haiti is shown in Figure 1. Approximately 1.5 million people were directly affected, and more than 220,000 people lost their lives (Government of the Republic of Haiti 2010). The scale of damage and destruction inflicted upon the country highlighted the vulnerabilities of existing infrastructure and the absence of adequate disaster preparedness and mitigation practices. These deficiencies were rooted in inadequate economic resources and a weak Haitian Government, unable to effectively respond to the crisis (Government of the Republic of Haiti 2010). Adding to this, the Haitian Government was ill prepared to handle a disaster of this size, requiring them to immediately request aid from external sources (Margesson & Taft-Morales 2010). The destruction and congestion left in the quake’s aftermath delayed distribution of aid to the population (United Nations Office for the Coordination of Humanitarian Affairs 2010), further deteriorating the success of the disaster

[3] Media reports were used; however, media content was always cross checked and validated through other sources.
[4] Information bins included: vulnerable sectors, disaster preparedness, governance, threats, vulnerability, aid, and aid providers.

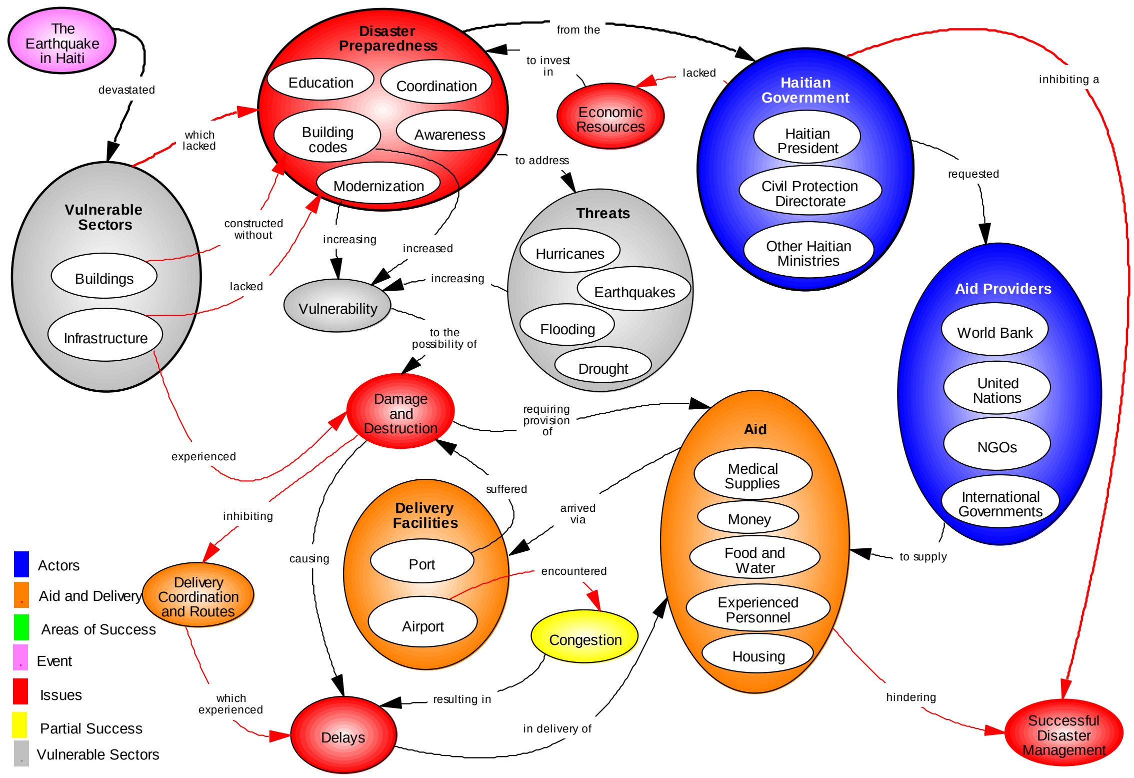

Figure 1: Haiti systemigram

management efforts.

Several actions prior to and immediately following the earthquake hindered Haiti's overall management and response. The death toll and devastation was tremendous (Government of the Republic of Haiti 2010). With extensive media coverage, Haiti's plight came to the world's attention. Aid providers were quick to pledge aid, and in many cases were quick to send aid to the country. However, the damage to the infrastructure coupled with the overwhelming aid push, created delays, with lapses in organization as well as delivery and distribution issues (Margesson & Taft-Morales 2010).

The Haiti earthquake systemigram highlights the various aspects of the Haitian disaster management system. Individual systemigram strands provide additional insight into specific elements that affected the overall success of the management of the disaster. The systemigram helped describe the disaster management system and underscored the importance of specific system elements that impacted the response outcomes.

Chile Earthquake Systemigram. Six weeks after the earthquake in Haiti (February 27, 2010), an even stronger earthquake hit Chile. The systemigram in Figure 2 shows a high level view of the Chilean disaster management system for a severe earthquake. 486 people lost their lives and 1.8 million were affected in the disaster (USAID 2010). However, compared to the earthquake in Haiti, the scale of damage and destruction was countered by Chile's strong disaster preparedness and mitigation practices. This preparedness stemmed from active government involvement in strengthening national infrastructure and in creating and enforcing strict regulations (Barrionuevo & Robbins, 2010). Additionally, recent economic growth has provided funding to finance projects securing the nation's disaster response capabilities (Mia, Estrada, & Geiger 2007). Chile also benefitted from dealing with earthquakes in the past, and unlike the Haitian Government, the Chilean Government was able to draw from prior experience and invest in appropriate disaster preparedness.

After the earthquake, the Chilean Government recognized that due to the level of damage and destruction, recovery efforts would require foreign assistance. They assessed the situation internally before requesting external aid. Utilizing this approach, Chile was able to request specific aid items (United Nations 2010). This approach, coupled with strong disaster preparedness, planning, and management procedures, allowed Chile to properly manage and coordinate relief assistance. Although there were some relief delays to overcome due to infrastructure destruction (United Nations 2010), the overall management and response effort was a success.

The purpose of the systemigram depicting the Chilean earthquake was to understand the various aspects of the Chilean disaster management system. A strand by strand analysis shows that although some elements hindered the success of the disaster response, several elements supported the relief effort.

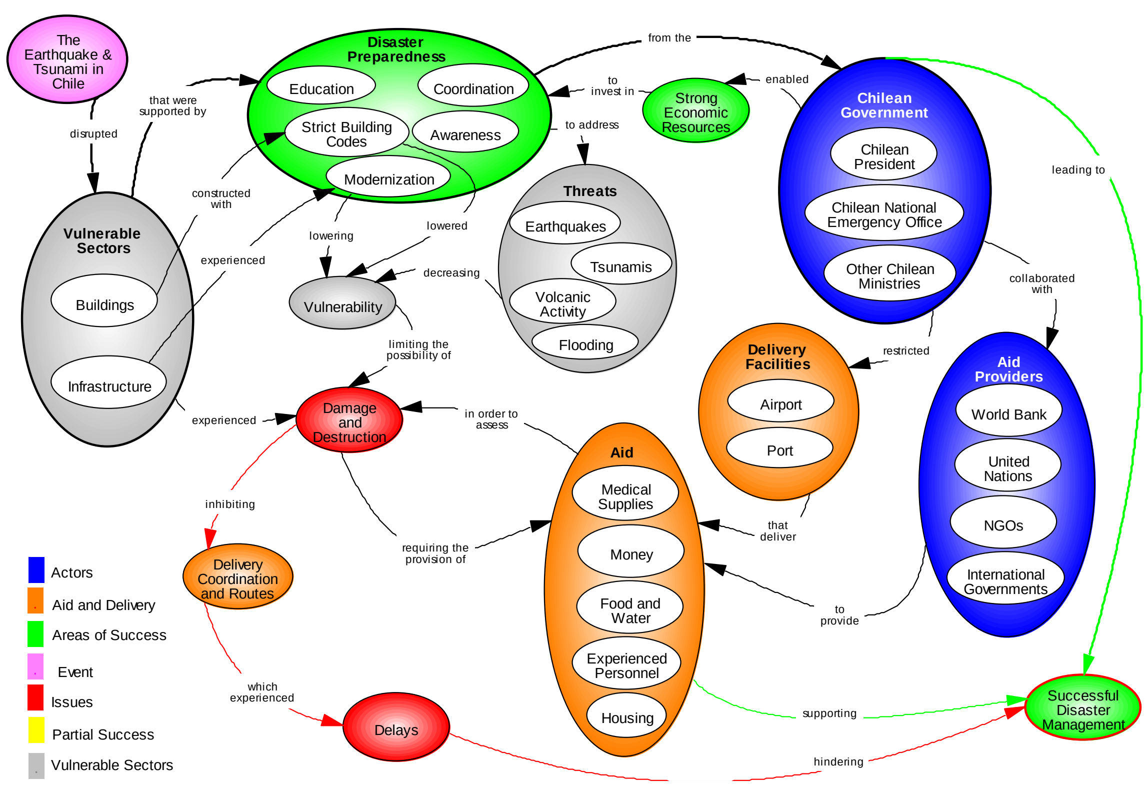

Figure 2: Chile Systemigram

Development of a System Template

The systemigrams illustrating the earthquakes in Haiti and Chile were previously restructured in a similar fashion with a common color scheme. In further comparing them, it became apparent that one system, Chile, experienced more success than the other system, Haiti. The color coding allowed this information to emerge quickly. From this comparison, a template for successful disaster management was created.

Generic Template. The overarching template is presented as a systemigram to aid understanding. In showing a successful disaster management system, whether in response to a natural or manmade disaster, the systemigram generally follows a particular stream of events. Broad in scope, the template assists users in quickly organizing information about a disaster by reminding analysts what to look at.

Using systemigrams to compare systems and, specifically using a systemigram-based template for disaster management, can help with understanding the causes of success or failure in a disaster management system. Deviations from this template can be further analyzed so as to determine failure points or anomalies. In determining failure points, further analysis can be done to improve performance and determine where to implement best practices. Deviations from the template also allow for areas to be highlighted and brought to the analyst's attention. Upon testing the template with additional systems, deviations may warrant a template modification.

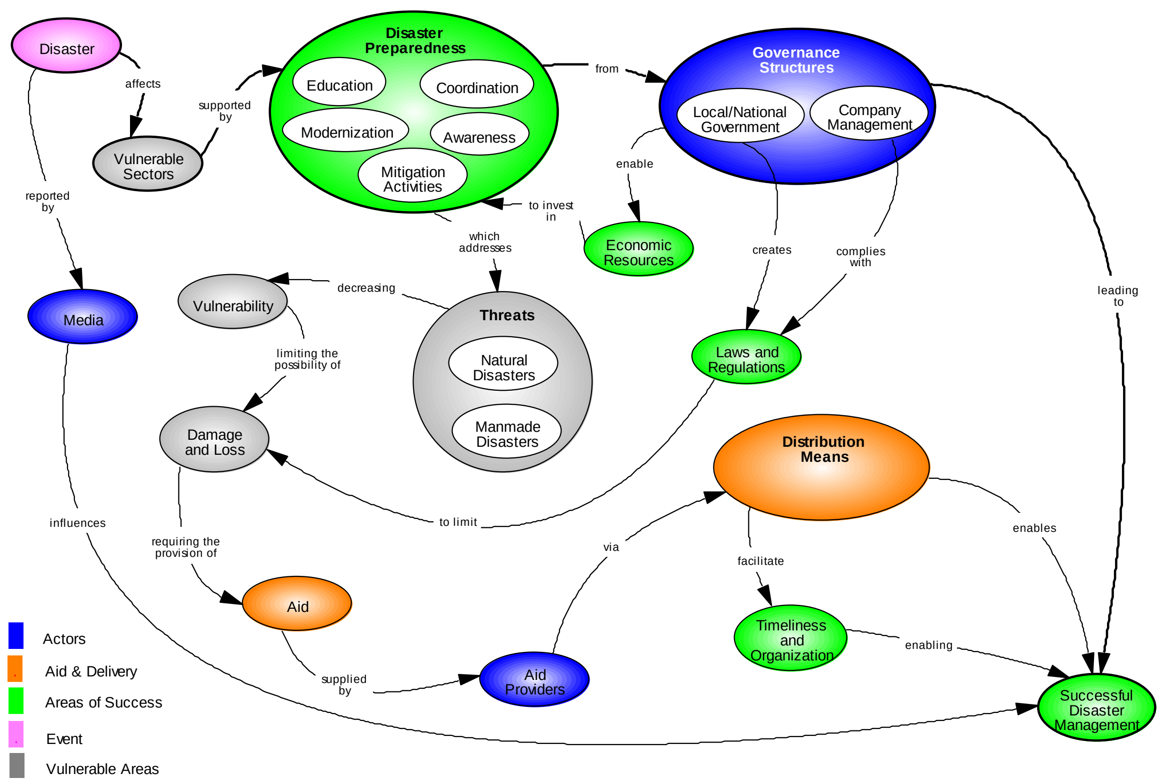

Figure 3: Generic Template Systemigram

Template Validation

The generic template was tested through two other events involving disaster management: the 2008 earthquake in Sichaun, China, and the 2010 oil spill in the Gulf of Mexico. These tests not only serve to demonstrate the usefulness of systemigrams in developing system templates, but also show the applicability of the template in varying types and scales of disasters.

China Systemigram. The systemigram shown in Figure 4 illustrates a high level view of the Chinese disaster management system for the earthquake that occurred on May 12, 2008 in Sichuan Province. The scale of damage and destruction was immense. Prior to the earthquake, the Chinese Government implemented several new laws and regulations; however, in spite of their existence, they were often ignored and unenforced. This greatly contributed to the extensive devastation (United Nations Economic and Social Council 2009). Additionally, as key infrastructure was not adequately protected, delays in responding to the earthquake were widespread as the damaged infrastructure inhibited relief efforts (USAID 2008).

Although the devastation was immense, China's rapid response to the earthquake was commendable. Resources, such as aid and skilled personnel, were mobilized quickly and deployed to the affected region. The country had plans and the necessary mechanisms to swiftly respond to the quake (United Nations Economic and Social Council 2009). Although slowed by damaged infrastructure, the government continued to send support to the affected region.

This systemigram was created in order to test the generic disaster management systemigram template (Figure 3). Analyzing elements of preparedness and response related to the China earthquake reveals that several elements are consistent with those found in the generic systemigram template. Using the systemigram template for a successful disaster management system to look at the China earthquake allows us to identify successful elements, as well as elements that warrant further investigation as problematic issue-areas or anomalies.

The China earthquake systemigram demonstrates how deviations from the template for success result in failures. Nodes that represent deviations (Figure 4) are colored red. Areas where

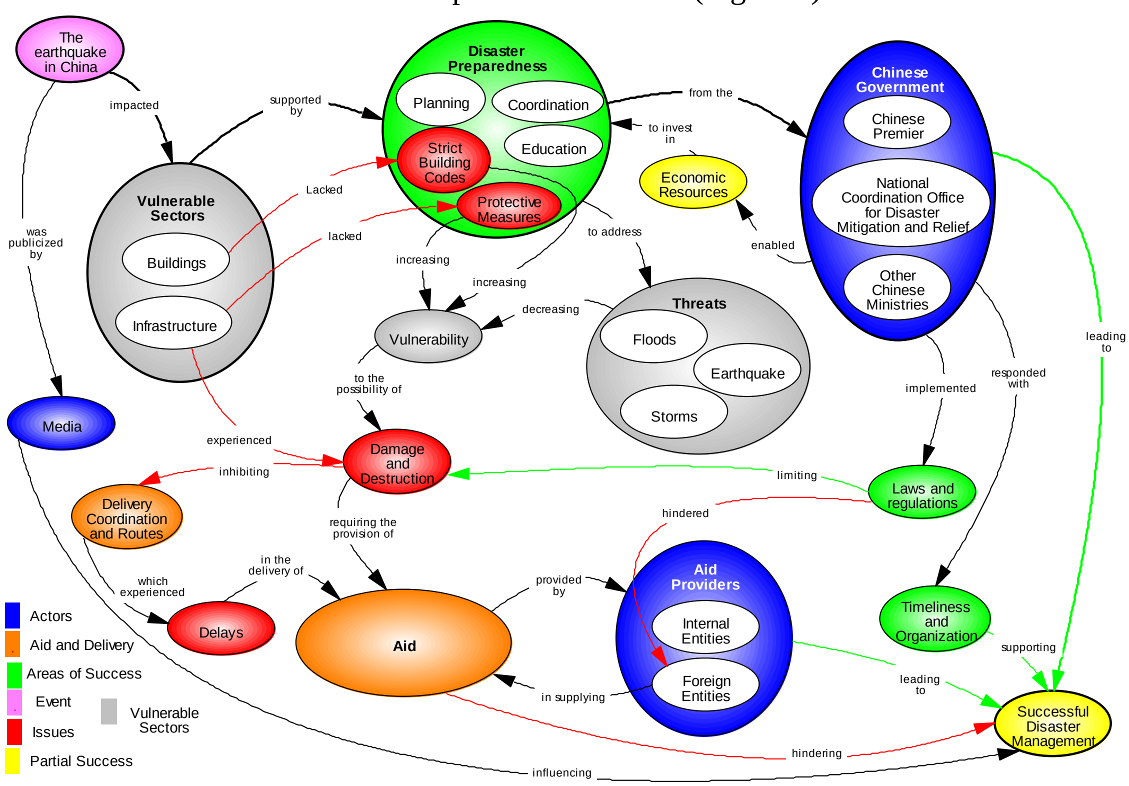

Table 4: China Systemigram

the China response deviates from the template for success are failure points and account for delays, increases in damage, and loss of life. For example, if laws and regulations had been enforced, damage would have been mitigated. Since laws and regulations were not enforced the damage and destruction from the earthquake was much higher than it could have been. Similar cases can be made regarding the lack of strict building codes and unprotected infrastructure.

Gulf Oil Spill Systemigram. After looking at three natural disasters, the next step was to apply the generic disaster management template to a manmade disaster. The manmade disaster chosen was the 2010 oil spill in the Gulf of Mexico, depicted at a high level in Figure 5.[5]

In April 2010 in the Macondo region of the Gulf of Mexico, an oil rig exploded. Following the explosion, oil began leaking out of the unplugged well and into the Gulf of Mexico. The oil leak continued for more than three months before a cap, capable of temporarily blocking the flow of all oil was placed on top of the well (Blackburn & Muir 2010). In the time between the initial explosion and the fitting of a temporary cap, significant oiling of the coasts and coastlines occurred in the Gulf States region, including: Louisiana, Alabama, Texas, Mississippi, and Florida. This oiling caused damage and destruction to the area's environment and economy (Gulf Coast Catastrophe 2010). Using the generic systemigram template to conduct a thread by thread comparative analysis one can identify the points from which the oil spill veered from the template of successful disaster management. Specifically, preparation for responding to an oil spill was limited by the lack of enforcement on regulations (Berkowitz & Stanton 2010).

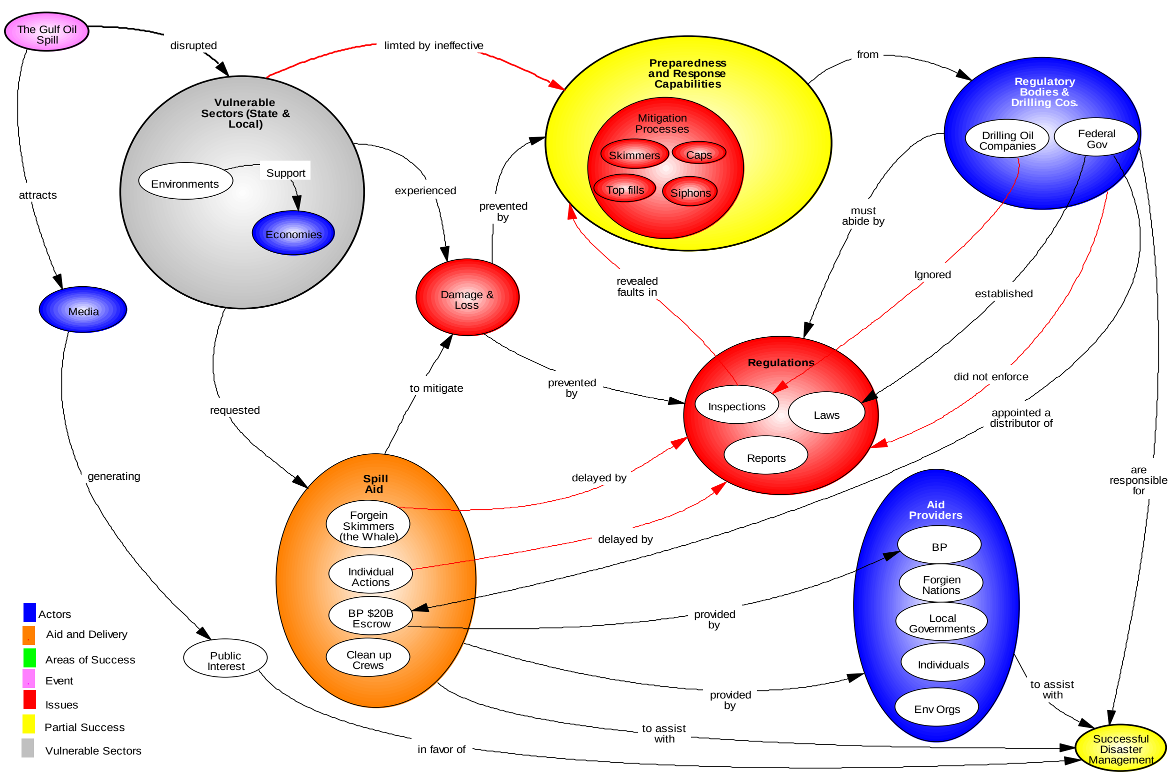

Table 5: Gulf Oil Spill Systemigram

---

5 This illustration reflects research conducted at a single point in time during an event. We did not go back and reassess the event as the results would not change our assessment of systemigram-based template use.

Furthermore, response was limited by a preparedness plan that did not account for the need of external aid providers. Therefore, acceptance of external aid was delayed, which further confounded the management activities.

In analyzing the Gulf oil spill, there were several elements that deviated from the generic template.[6] However, the template still proved useful as it assisted in guiding and determining the applicability of particular elements. Additionally, in comparing the oil spill to other disasters, it became apparent that critical failure points appear in similar areas between the different disasters.

Summary

Looking at the disaster management systemigrams for the Haitian and Chilean earthquakes, a generic disaster management systemigram-based template was created. In testing the systemigram-based template, it was applied to another earthquake (China 2008) and the 2010 Gulf oil spill. The systemigram template and systemigram comparison enabled identification of leverage points for disaster management, specifically pointing to factors that influence the success or failure of the disaster management system.

Ultimately, this paper has shown that systemigrams can be used as a tool to compare systems, and that systemigram-based templates are particularly useful in helping collect and organize system related information. To further reinforce the findings, determine use of the template in future response planning, and establish practices to limit and mitigate disaster devastation, systemigrams and systemigram templates should be applied to additional disaster events. Furthermore, systems outside of the disaster management domain should be analyzed to refine the use of systemigrams and systemigram templates in system analysis.

References

Barrionuevo, A., & Robbins, L. (2010). 1.5 million displaced after Chile quake. *The New York Times*. Retrieved from http://www.nytimes.com/2010/02/28/world/americas/28chile.html

Berkowitz, B., & Stanton, L. (2010, May 13). "House panel: Flaws in the well." *The Washington Post*. Retrieved from http://www.washingtonpost.com/

Blackburn, B. & Muir, D. (2010). "Gulf of Mexico oil spill: Well integrity test shows oil stopped." ABC World News. Retrieved from http://abcnews.go.com/WN/gulf-oil-bps-cap-success-oil-stops/story?id=11173330

Boardman, J., & Sauser, B. (2008). *Systems thinking: Coping with 21st century problems.* Boca Raton: CRC Press.

Government of the Republic of Haiti. (2010). *Haiti: Executive summary of the PDNA after the earthquake sector evaluation of damage, losses and needs*. Retrieved from http://site resources.worldbank.org/INTLAC/Resources/PDNAExecutiveSummary.pdf

Gulf coast catastrophe: Assessing the nation's response to the deepwater horizon oil spill.

[6] Deviations listed are not exhaustive, given the space constraints of this paper only a selection has been included.

(2010) (testimony of Secretary Janet Napolitano). Retrieved from http://www.dhs.gov/ynews/testimony/testimony_1274125488135.shtm

Margesson, R., & Taft-Morales, M. (2010). Haiti earthquake: Crisis and response. *Congressional Research Service.* Retrieved from http://www.crs.gov

Merriam-Webster (2011). Retrieved from http://www.merriam-webster.com/

Mia, I., Estrada, J., & Geiger, T. (2007). "Benchmarking national attractiveness for private investment in Latin American infrastructure." *World Economic Forum*. Retrieved from http://www.weforum.org/reports-results?fq=report%5Edate%3A2007

United Nations. (2010) "Press conference on Chile by deputy emergency relief coordinator." Retrieved from http://www.un.org/News/briefings/docs/2010/100302_Bragg.doc.htm

United Nations Economic and Social Council. (2009). "Implementation of the hyogo framework for action in Asia and the Pacific: Case study: The national disaster management system of China and its response to the Wenchuan earthquake." Bangkok: Author. Retrieved from www.unescap.org/idd/events/cdrr-2009/CDR_2E.pdf

United Nations International Strategy for Disaster Reduction. (2006). Retrieved from http://www.unisdr.org/disaster-statistics/occurrence-trends-century.htm

United Nations Office for the Coordination of Humanitarian Affairs. (2010). [Map illustrating the Haiti earthquake humanitarian operation challenges January 18, 2010]. "OCHA situation report 7." Retrieved from http://www.reliefweb.int/

United States Agency for International Development. (2010). "USAID responds to Chile Earthquake." Retrieved from http://www.usaid.gov/helpchile/

United States Agency for International Development. (2008). *China: Disaster response updates.* Retrieved from http://www.usaid.gov/our_work/

Biographies

Jamie Mussante is an Associate Analyst with Analytic Services Inc., providing research and analysis support to the Applied Systems Thinking Consulting Group as well as the Applied Systems Thinking Institute (ASysT). Jamie has a BA in International Relations from Boston University and is working towards her MA in Political Science at George Mason University.

Jaime Frittman is the Technical Manager of the Applied Systems Thinking Consulting Group at Analytic Services Inc. Jaime has 10 years experience in emergency management, chemical, biological, radiological, and nuclear (CBRN) defense, requirements generation, and system analysis. Jaime has a BA in Psychology and a Master's of Engineering in Systems Engineering.

Robert Edson is Vice President for Enterprise Development at Analytic Services Inc., and Director of the Applied Systems Thinking Institute (ASysT). In his role as Director of ASysT, he leads an institute whose mission is to advance the application of systems thinking principles in the fields of national security and homeland security. He has over 25 years of experience in dealing with complex systems issues and systems thinking. Robert is an Adjunct Professor at Stevens Institute of Technology and has a BS in Biology from George Mason University and a MS in Physical Oceanography and Meteorology from the Naval Postgraduate School.