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"Assessment of C2 Maturity against the Background of Complexity of Disaster Relief Operations: Two Case Studies of the Tsunami 2004 and Elbe Flood 2002"

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Assessment of C2 Maturity against the Background of Complexity of Disaster Relief Operations: Two Case Studies of the Tsunami 2004 and Elbe Flood 2002

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Abstract

The NATO RTO Research Study Group SAS-065 is currently developing a conceptual maturity model defining C2 maturity levels required to achieve requisite levels of network-enabled capability for complex NATO endeavors. The development of this NATO NEC C2 Maturity Model (N2C2M2) includes a series of validation case studies to investigate whether or not the observations available from case studies support the assumptions underlying the model as a basis for its iterative improvement.
This paper presents two case studies on the response to recent natural disasters, the Indian Ocean Tsunami of 2004 and the Elbe Flood of 2002 in Germany, involving military and a variety of non-military entities including non-governmental organizations. Supplemented by various web accounts, both case studies are based mainly on reports by commissions tasked, by the UN and the Saxony state government respectively, to investigate the management and effectiveness of the response operations and make recommendations for improvement. The findings of the case studies are largely in line with the assumptions underlying the N2C2M2, the considerable differences of both operations in terms of scale, degree of preparedness, and the management of response resources notwithstanding. The comparison of the findings of both case studies supports the hypothesis of requisite maturity of C2 in that the lower complexity of the Elbe Flood operational environment enabled better use of available resources even though the structural maturity of the German C2 approach seemed not significantly higher than in the Tsunami case where C2 of international aid was quickly overwhelmed, however, by the high complexity of the operational environment.

Keywords: Maturity Model, C2 Assessment, Complexity, Tsunami, Elbe Flood, Case Study

Introduction

NATO is developing the capability to conduct network-enabled operations. The respective ability, referred to as Network-Enabled Capability (NEC), is considered critical for mission success in the challenging complex civil-military operations in which NATO will participate in the twenty-first century (Alberts & Moffat, 2007a).
To support NATO NEC development the NATO RTO Study Group SAS-065 is tasked with the development of a NATO NEC Command and Control (C2) Maturity Model[1] (N2C2M2) designed to provide guidance for the assessment of C2 approaches and capabilities under the conditions of Network Centric Warfare (NCW). The development of N2C2M2 includes a series of validation case studies to investigate whether or not the observations available from case studies support the assumptions underlying the model as a basis for its iterative improvement. The N2C2M2 supports military organizations to determine where they are and where they want to go regarding C2 capabilities relative to those prescribed by the NCW

[1] The term Maturity Model was originally coined in the context of evaluating the maturity level of software development processes (Paulk, et al., 1993). The Capability Maturity Model (CMM) is designed to assist software organizations in selecting process improvement strategies by determining current process maturity and identifying the key issues most critical to software quality and process improvement.

vision (Alberts & Hayes, 2007). It identifies important milestones that need to be reached on the road to higher C2 maturity by nations who seek to contribute to Nato NEC by developing requisite C2 approaches and capabilities. It provides a framework that can be used to assess the C2 capabilities of individual nations and collections of nations and other coalition partners. For information on the current state of model development the reader is referred to two working papers: 1) SAS 065: NATO NEC C2 Maturity Model Overview (SAS 065, 2007); 2) Description of Maturity Levels (Alberts & Moffat, 2007).This paper presents two case studies on the response to recent natural disasters, the Indian Ocean Tsunami of 2004 and the Elbe Flood of 2002 in Germany, involving military and a variety of non-military entities including non-governmental organizations. In both case studies a series of documents are evaluated to identify the facts relevant for the assessment of C2 maturity on one hand and the complexity of the operational space of the respective disaster response operation on the other. The findings of both case studies are largely in line with the assumptions underlying the N2C2M2, the considerable differences of both operations in terms of scale, degree of preparedness, and the management of response resources notwithstanding.
A comparison of the findings supports the hypothesis of requisite maturity of C2 in that the lower complexity of the Elbe Flood operational environment enabled better use of available resources. The overall C2 maturity level (ML) during the Elbe Flood national response operations can be classified as coordinated C2 which was assessed in the respective lessons learned reports as being the appropriate C2 maturity level for dealing with such disasters. In contrast, despite many incidents of conflicted C2, and coordinated and collaborative C2 in a few cases, the overall C2 ML of the massive international Tsunami response may be assessed as having been de-conflicted C2, albeit at the lower end of its margin. The lessons learned reports support the view that, in addition to improving local preparedness and response capabilities, an efficient management of the response to disasters on the sale of the 2004 Tsunami requires collaborative C2 approaches to be developed between the main actors
This paper is organized as follows. In the next section we present a brief outline of the N2C2M2, followed the criteria so assess complexity of disaster relief systems. The main two sections of this paper are dedicated to the two cases with description of the case and case analysis. The paper is concluded with a comparison of cases and the results of the analyses and a summary of the insights.

The NNEC C2 Maturity Model: Maturity Levels and Supporting Observations

The N2C2M2 developed by SAS 065 describes the five ML representing different levels of C2 capability: Conflicted, De-conflicted, Coordinated, Collaborative, and Agile C2 featuring the following characteristics (Alberts & Moffat, 2007b) and (Alberts & Hayes, 2007)[2]:

Conflicted C2: The only existing C2 is that which is exercised by the individual contributors over their own forces or sub-elements. Conflicted C2 is characterized by each entity pursuing its individual intent and taking independent action. Thus, entities are operating without communicating, sharing information with, or engaging in any C2-related interaction with each other. This means that there is no way to avoid some “negative cross-impact” between or among the participating entities.

De-conflicted C2: In order for entities to avoid negative cross impacts of their intents, plans, or actions they need to be able to recognize potential conflicts and attempt to resolve them

[2] These levels are fractal. This means that they can be applied, at least in theory, to groups of individuals and organizations of any size (Alberts & Hayes, 2007). The ML corresponds to the collective C2 approach of at least two contributing entities and does not assess the individual C2 approaches of each entity.

by partitioning the problem space as a function of, for example, geography, function, and/or time. This involves limited information sharing and limited interactions.

Coordinated C2: Overall C2 effectiveness is increased by seeking mutual support for intent, developing relationships and links between and among entities' plans and actions to reinforce or enhance effects, some initial pooling of non-organic resources[3]. This in turn requires a significant amount of information sharing (broader dissemination) and a richer set of interactions, both formal and informal (relative to those required for de-confliction) among those in the various elements that are involved in establishing intent and developing plans.

Collaborative C2: Significant synergies are developed by negotiating and establishing shared intent and a single shared plan, establishing or reconfiguring roles, coupling actions, rich sharing of non-organic resources, some pooling of organic resources[4], and increasing interactions in the cognitive domain to increase shared awareness. The intents of the entities/elements are subordinated to a shared intent unless they do not conflict with or detract from shared intent. Similarly, entity plans need to be supportive of the single integrated plan. Entities operating at this level of C2 maturity accept symbiotic relationships and are interdependent. Very frequent interactions, indeed approaching continuous interaction between/among identified individuals/organizations, involving richer and more extensive interchange in both the information and cognitive domains, is required to establish shared understanding and the development of a single plan.

Agile C2: Building on Collaborative C2, Agile C2 is distinguished by the entities' capability to self-synchronize as well as the ability to recognize which approach to C2 is appropriate for the current situation and to adopt that approach in a dynamic manner. The ability to self-synchronize requires that there exists a rich shared understanding across the contributing elements. This in turn requires a robustly networked collection of entities with widespread and easy access to information, extensive sharing of information, rich and continuous interactions.

Based on these descriptions of the ML characteristics, one arrives at the essential observations listed in Table 1 as deduced from the facts identified in the case study documents.

Conflicted	De-Conflicted	Coordinated	Collaborative	Agile
• Communication and sharing of information cannot be observed. • Actions of different entities interfere adversely with each other	• Limited interactions about plans • Willingness to change plans to avoid negative cross impacts • Few negative cross impacts of actions	• Interactions, information sharing and coordination of entities' plans • Willingness to change own plans to support other entities' plans • Synergies of linked plans and actions • Sharing of non-organic resources	• Very frequent interactions in the information and cognitive leading to trust between entities • Collaborative development of a single plan, shared intent and shared Awareness • Interdependencies between involved entities • Sharing of organic resources	• Rich and continuous interactions • Rich shared understanding across all contributing entities • Dynamic adaptation of C2 approach to the situation • Self-synchronization of participating entities

Table 1: Observations Indicative of C2 Maturity Level

[3] Non-organic resources are resources not "owned" by participants, e.g. bridges, roads.

[4] Organic resources are those "owned" by a participant. They may include vehicles, weapons, and local supplies.

Complexity

To compare the complexity of operations we identify relevant dimensions of complexity and analyze how complexity changes along them. Following Mitleton-Kelly (Mitleton-Kelly, 2003), the following six dimensions are selected for our case studies:

1. connectivity,
2. interdependence,
3. co-evolution,
4. far-from-equilibrium,
5. space of possibilities and
6. self-organisation.

Connectivity & Interdependence

Connectivity describes the number, nature and degree of connections and interactions between elements of the system. The degree of connectivity is an indicator of the extent of coupling of and the dependencies between elements (Mitleton-Kelly, 2003).
Interdependence of elements is indicative of the strength of cohesion of a system regarding decision-making, cooperation and communication.
Both dimensions are important for the diffusion of information and ideas throughout the system and to bring together the appropriate skills for solving the emerging problems and tasks. However, connectivity and interdependence also imply that disturbances or perturbations might ripple through and be amplified within the system. Also, the improvement of fitness or position of certain elements might adversely affect the fitness of others (Mitleton-Kelly, 2003; Mitleton-Kelly & Land, 2006).

Co-evolution

Co-evolution (of systems) involves the process of mutual change of systems and their environment. Changes within a system are defined as adaptation processes (Mitleton-Kelly & Land, 2006). In complex environments technical and social evolution can be considered a search of possibilities across “fitness”, cost or efficiency landscapes that are multidimensional and mountainous and full of locally optimal solutions (Kauffman & Macready, 1995). Co-evolution in social systems can therefore be seen as “reciprocal influence leading to change in the co-evolving entities” (Mitleton-Kelly & Land, 2006).
Co-evolution is largely non-deterministic. Thus, its path is hardly predictable but may only be revealed retrospectively (Mitleton-Kelly & Land, 2006). Therefore, planning in complex systems cannot be based on the study of reaction patterns only. Its elements must have sufficient agility to cope with unforeseen events in meeting their objectives captured by shared intent (Alberts & Hayes, 2007).

Far from Equilibrium

The term “Far from Equilibrium” originates from the work done by Ilya Prigogine and his co-authors (e.g. Nicolis & Prigogine, 1989). Simply put, it denotes a disturbance of the equilibrium of physical/chemical systems where the ensuing processes lead to a new equilibrium. Their ideas have been adopted by social scientists (e.g. Mitleton-Kelly, 2003a; Mitleton-Kelly & Land, 2006) to describe the behaviour of complex social systems which, when disturbed by endogenous or exogenous events (e.g. socioeconomic or environmental

crises or human interventions), have the capability to operate far from the original equilibrium to eventually find a new one that may, however, not be predicted. In that sense the dimension "Far from Equilibrium" characterizes the disruptions caused by the natural disasters described in our case studies which disaster response operations attempt to address given the situational restrictions and without being able to predict their outcomes.

Space of possibilities

This dimension refers to the number and variety of ways in which things are done to arrive at a new equilibrium for a disturbed system. To control a complex system it takes variety (Ashby, 1957). In other words, the higher the variety of action options, the higher is the likelihood to find a new equilibrium the unpredictability of which, however, requires that social systems develop a culture of continuous change.

Self-organisation

"Self-organisation is a dynamical and adaptive process where systems acquire and maintain structure themselves, without external control." (De Wolf & Holvoet, 2005). Structure implies spatial, temporal or functional aspects. "Without external control" describes the absence of manipulation, direction, involvement, interference or pressure from outside the system. It does not include data inputs from outside the system unless the data refer to control-instructions.

The Indian Ocean Tsunami 2004

Overview

The Indian Ocean Tsunami of 26 December 2004 is believed to have been the deadliest natural disaster in modern history. Triggered by slippage of about 1000 km of the boundary between the India and Burma plates off the west coast of northern Sumatra, the ensuing tsunamis flooded coastal areas, wiping away homes and buildings, roads and bridges, water and electricity supplies, crops, irrigation and fishery infrastructure, food and fuel networks, killing over 227,000 and displacing some 1.7 million people in 14 countries around the Indian Ocean (see Figure 1). Indonesia, Thailand, India, Sri Lanka, and the Maldives were the countries hit hardest. A massive media-fuelled global response generated an unprecedented US$ 13.5bn in international aid.

After the Tsunami most of the search and rescue and live saving activities were done by local people. Survivors were rescued by their neighbours and by other survivors using whatever means were at hand. Surviving doctors, nurses and paramedics rendered first aid in makeshift or remaining health centers. Despite the scale of the disaster and the loss of government leadership[5] many communities coped effectively on their own during the first days after the disaster. Teams formed spontaneously, organized themselves, and private and public vehicles and boats, offices, schools, temples, and homes became were immediately available. Food was provided from local shops until external help arrived. Both national and international responses were slowed by the time it took to form a full picture of the extent of damage. This was especially true in the case of Aceh where the destruction cut normal communication lines. It was only when he arrived in Aceh on 27 December that the Vice President of Indonesia and his advisors fully understood the extent of damage leading to the request for foreign assistance and the decision to allow international agencies access to Aceh. Eventually,

[5] In Aceh, about 60 senior leaders of civil society and 5,200 staff from local authorities died and another 2,300 were missing.

military forces from 13 countries aided the Indonesian military with helicopters, field hospitals, and logistics assets. Overall 21 countries deployed military assets throughout the affected region. Numerous international organisations and thousands of aid workers arrived in response to the massive media campaign proclaiming that any hand was needed.[6] Annex A gives an overview on major agencies and organizations engaged in the Indian Ocean Tsunami response and their approximate arrival times in Aceh.

Figure 1: Countries affected by the Indian Ocean Tsunami of 26 December 2004

Many problems in coordinating the aid efforts were observed during the Indian Ocean Tsunami. Triggered by private messages of foreign tourists to their relatives at home and early internet newswire reports, journalists virtually descended on the disaster areas, making the tsunami a global news event that generated an unprecedented willingness to help. However, contrary to what one would naively expect, the abundance of international aid that was mustered within a few days of the event was a powerful factor contributing to the inefficiency of aid delivery as described in Telford and Cosgrave (2006).

The International Disaster Response Process[7]

In crisis situations and natural disasters, foreign aid is either requested by or offered to governments of the affected countries by nation states or the international community through the United Nations. In case of natural disasters this is the case when national relief resources

[6] For example, in one location of India (Nagapattinam District), there were 150 registered and presumably the same number of unregistered NGOs. In Banda Aceh, the number of international NGOs increased from about 50 in early January to 180 in June, in addition to about 430 local NGOs.

[7] This chapter is adapted from "OCHA at work: Coordination and the Indian Ocean Tsunami" (OCHA Homepage).

are insufficient to cope with consequences. While differing in detail, national disaster response is usually organized hierarchically – from local populations and authorities to provincial and state authorities and national government – with resources (including civilian agencies and organizations as well as national militaries) being activated upon requests from lower levels. The ultimate authority for the coordination of relief operations and resources commonly rests with crisis management groups involving representatives of the activated levels.

In general, international response is coordinated by the Geneva-based UN Office for the Coordination of Humanitarian Affairs (OCHA) through the Interagency Standing Committee (IASC) chaired by the UN Relief Coordinator (ERC). IASC participants include all humanitarian partners, from UN agencies, funds and programmes to the Red Cross Movement and non-governmental organizations (NGO). IASC ensures inter-agency decision-making in response to complex emergencies. As a rule, the response includes:

- needs assessments,
- consolidated appeals for financial support of response plans, including substantiated cost estimates, as a basis for voluntary commitments by UN member countries,
- field coordination arrangements including, if necessary, an IASC replication in the field and
- the development of humanitarian policies.

OCHA disposes of about 1,100 staff members in New York, Geneva and in some 20 field offices. In case of a disaster, OCHA dispatches UN Disaster Assessment and Coordination (UNDAC) teams to the affected countries to establish and prioritize the needs for aid and allocate arriving aid organizations to efficiently meet the established needs consistent with the organizations' capabilities and support requirements.

Assessment of Complexity

The complexity of the Tsunami relief operations is assessed based on the six dimensions of complexity defined above. This analysis looks at the scenario in a holistic manner including the environment and the entities involved in disaster relief such as affected populations, official authorities, aid providers, and their interactions. An overall assessment of the complexity of the Tsunami disaster was made by Louise Comfort: *"As complexity increases with the size, scope, and severity of the event, the tsunami disaster was at the extreme end of the complexity continuum"* (Comfort, 2006).

Connectivity and Interdependence

Numerous national and international organisations arrived quickly in the affected areas. In principle, they all had the same objectives: providing aid and relief. However, there are numerous accounts of severe competition between them for prestigious projects, beneficiaries, facilities, materiel, and staff suggesting their interdependencies were quite adverse. Their work was largely uncoordinated both geographically as well as functionally. Figure 2 shows the results of an interaction analysis conducted by Comfort (2006) based on Indonesian newspaper reports. It illustrates the manifold interdependencies and connectivity suggesting a high degree of complexity of the relief operations.

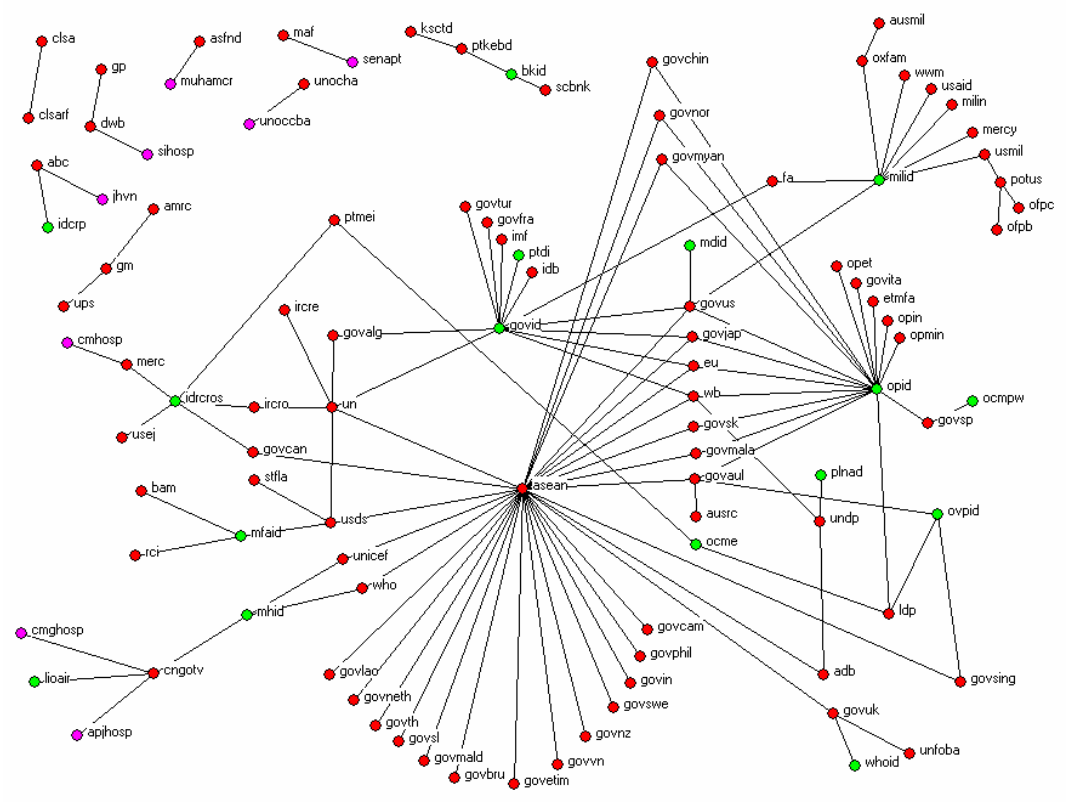

Figure 2: Map of Interacting Organizations (Comfort 2006)

Red nodes indicate international organizations, green nodes national organizations. A legend of acronyms is provided in Comfort (2006).
The figure shows a significant amount of interaction between involved organizations. The problems in coordinating them reported in Telford and Cosgrave (2006) lead to duplication of efforts and disregard of important aspects.

Co-evolution

From a higher vantage point, two interacting relief systems may be distinguished in the affected areas. One includes all elements describing the local situation after the Tsunami including infrastructure and political, social, cultural and military aspects relevant to immediate relief before foreign aid organizations entered the area. The other includes all elements arriving for follow-on relief including international governmental and non-governmental organizations.[8] Co-evolution between both systems can be observed in four main steps as shown in Figure 3. Triggered by the Tsunami, the iterative feed-back process of co-evolution is symbolized by the horizontal green arrows.

[8] This classification is more or less arbitrary and serves to illustrate the co-evolution. Many other partitions into interacting systems would also be plausible.

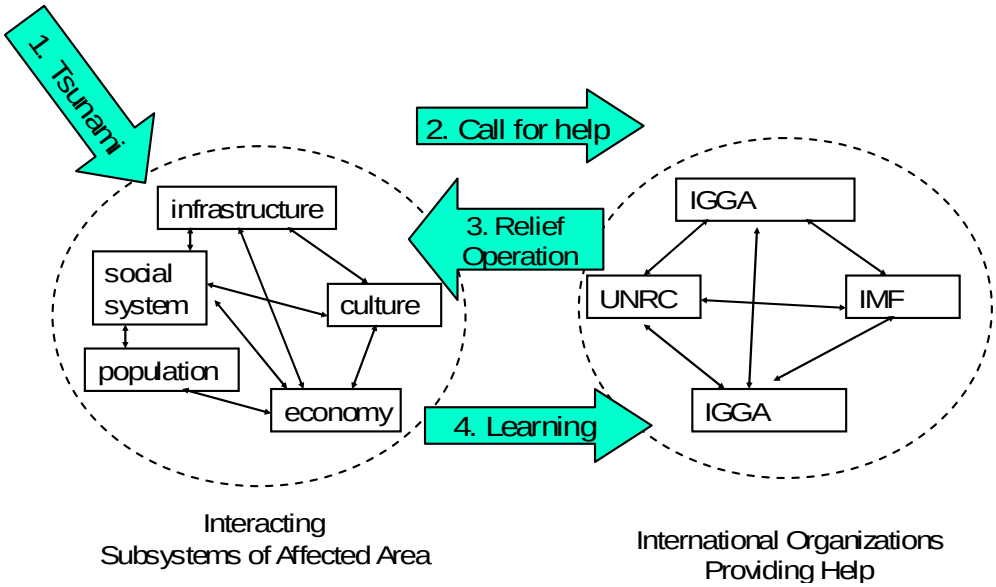

Figure 3: Co-evolution between Subsystems in the Tsunami Response Endeavour[9]

The non-deterministic nature of the co-evolution between the interacting aid systems is underscored by the fact that the arrival and emergent behaviour of aid organizations was not predictable nor were their functional capabilities. Institutional capabilities to coordinate relief tasks and the large number of arriving aid organizations were overwhelmed. Especially the unpredictability of the relief operations is indicative of their high complexity.

Far from Equilibrium

The Tsunami disrupted the entire socio-economic system in the affected areas and moved it far away from its normal state. To give an illustration of the disruptive change some figures from Telford and Cosgrave (2006) are listed in Table 2.

	Indonesia	Sri Lanka	India	Maldives	Thailand
Population loss (incl. missing)	167,540	35,322	16,269	108	8,212
Total Damages & Losses from tsunami, % of GDP	2.0	7.6	0.2	83.6	1.4
Damage to housing in %	47.9	36.0	33.6	20.9	4.3
Damage to physic infrastructure in %	21.8	23.9	13.6	27.3	5.3
Damage to productive sectors in %	12.1	31.8	46.1	28.4	88.6

Table 2: Impact of the Tsunami

In terms of complexity theory the change of the system caused by the Tsunami was at the upper end of the complexity scale. However, at this time it is too early to say whether or not the system has reached a new equilibrium. But many recommendations have been forwarded by involved organizations suggesting that they will re-organize and develop new procedures

[9] Abbreviations of international organizations are explained in Annex A.

(see for example Telford & Cosgrave, 2006). UNESCO is developing a worldwide Tsunami warning system.

Space of possibilities

Notwithstanding the overall intent of all aid organizations to provide aid and to improve the situation, their operations were largely uncoordinated. Each organization had to choose its own tasks from a huge space of possibilities. At the beginning of the relief operations there was widespread demand for food and water supply as well as reconstruction of communication lines. In terms of complexity theory, the space of possibilities facing individual organisation was large enough to classify their decision-making as complex.

Self-organisation

Self-organisation was observed in both the immediate and follow-on relief phases. During the immediate relief local population spontaneously provided first aid, organized transportation of casualties and made offices, schools, temples, and private homes available to accommodate victims and displaced persons. Food was provided from local shops. Both national and international responses were delayed because of the lack of information and slow damage assessment. Given the overwhelmed UN coordination capabilities, most of the positive results in the follow-on relief phase were achieved when international organizations with sizeable funding worked closely together with local organization knowing the local circumstances. In general, however, international aid was duplicated and inappropriate in many cases.[10] Thus, because of the large number of entities involved, the numerous tasks to be performed, and the lack of effective control capabilities there was a considerable need for self-organisation suggesting a high degree of complexity.

Composite Complexity

The Indian Ocean Tsunami was an extreme event - characterized by significant human losses and casualties and massive material damage in conjunction with a large number of actors with competing interests and initially largely dysfunctional coordinating institutions - the consequences of which produced a situation that is located at the upper end of the complexity scale.

Assessment of C2 Maturity

The assessment of C2 maturity for the Tsunami is focussed on the follow-on relief phase which began two days after the Tsunami hit when international aid organizations began to arrive.. A military contingent from Singapore was the first to reach the Indonesian province of on 28 December 2004, followed on 1 January 2005 by US, UK and some other countries beginning. They had their tasks allocated by the Indonesian military that had the detailed local knowledge required for an efficient needs-based assistance. Also on 28 December OCHA's UNDAC teams arrived in the hardest hit countries Indonesia, Sri Lanka, Thailand, and the Maldives. Simultaneously, national governments activated or created ad hoc disaster management authorities such as the National Disaster Management Board in Indonesia, the

[10] A considerable part of the inappropriate aid come from agencies with no expertise in international operations, especially some National Red Cross and Red Crescent Societies which had raised vast funds, notwithstanding the Red Cross Movement Protocol that supplies should only be sent in response to specific requests by local Societies.

Center of National Operations as the de facto National Disaster Management Authority in Sri Lanka, and the National Disaster Management Center in the Maldives. The Thai government responded by activating the Civil Defence Act under which the Ministry of the Interior coordinated the response of different line ministries. The Ministry of Foreign Affairs coordinated foreign assistance through the Ad Hoc Tsunami Task Force.

Telford and Cosgrave (2006) point out that the military played a key role in the tsunami disaster response because the international humanitarian system has a very limited standby capacity such as for airlifting. However, there was little joint planning and training between the military and the traditional humanitarian actors. Thus coordination between them was weak. In addition, NGO-military relations bordered on hostile, especially in Aceh. During the tsunami disaster relief phase, the Indonesian military was suspecting NGOs to be spies and supporters of Aceh's autonomy while the NGOs accused the military of unfair food distribution. The international militaries considered NGOs as ineffective and self-promoting. Thus, relationships as well as C2 between military and NGOs are assessed of having been conflicted. But also instances of good cooperation were reported implying coordinated C2 between International Organizations (IO) with local connections and Singapore, US, UK military support.

To facilitate coordination of aid, many agencies and governments posted situation reports on their websites. OCHA established Humanitarian Information Centers in Indonesia and Sri Lanka and established websites to facilitate information gathering and distribution. The UNDAC team report from Aceh was one of the earliest formal needs assessments, together with the UN Synthesized District Report in Sri Lanka. These assessments were very approximate and drew significantly on media reports. However, UNDAC teams were under-equipped with communication infrastructure and lacked important C2-functions and procedures (e.g. administrative procedures for quick purchase decisions). Nevertheless, the capacity of coordinating bodies was quickly exhausted as numerous IOs and thousands of aid workers and military units arrived in response to the massive media campaign proclaiming that any hand was needed. In addition, the proliferation of actors to be coordinated combined with deep pockets of money meant that they had little interest in common services, which made coordination extremely difficult, not to speak of the lack of continuity, skills and experience among some of the UN coordinators. IOs did not appoint special liaison officers to deal with the large number of other agencies and NGOs. Furthermore, due to their large number and diversity, many of the NGOs were insufficiently presented in coordination bodies and coordinated poorly among themselves..

Also within IOs such as the Red Cross (RC) problems were reported that could have been rooted in the practised C2-approach. For example, when a national RC agency is responding to an emergency it is supposed to work through the National RC Society of the affected country and/or the International Federation of the Red Cross (IFRC). Despite this arrangement the Indonesian and Sri Lankan National Societies soon faced problems with unwanted and inappropriate donations from other National Societies (fishing boats supplied by Kuwait via the Kuwaiti Red Crescent Society that were inappropriate for use in Aceh). Thus, at least in part RC C2 was conflicting. Coordination structures also presented a problem. As a rule, they were fragmented into sectoral groups which inhibited integrated planning within any specific geographical area, resulting in conflicted C2 and disjointed operations.

Telford and Cosgrave (2006) list four major recommendations for the re-organization of international aid:

1) The international humanitarian community needs a fundamental reorientation from supplying aid to supporting and facilitating communities' own relief and recovery priorities.

2) All actors should strive to increase their disaster response capacities and to improve the linkages and coherence between themselves and other actors in the international disaster response system, including those from the affected countries themselves.
3) The international relief system should establish an accreditation and certification system to distinguish agencies that work to a professional standard in a particular sector.
4) All actors need to make the current funding system impartial and more efficient, flexible, transparent and better aligned with principles of good donorship.

Summary

During follow-on-relief most actors/organizations were able to at least de-conflict their interactions with other parties except for most IOs, especially international NGOs, which were not very interested in coordinating activities among each other for the reasons discussed above. The remaining interactions can be described as coordinated. Only a few collaborative interactions were observed such as between national and international militaries and between NGOs and local/national organizations that had established mutual trust through previous cooperation. The observed C2 Maturity between interacting groups of organizations is visualized in the respective working paper of SAS 065 by the viewgraph presented in Figure 4.

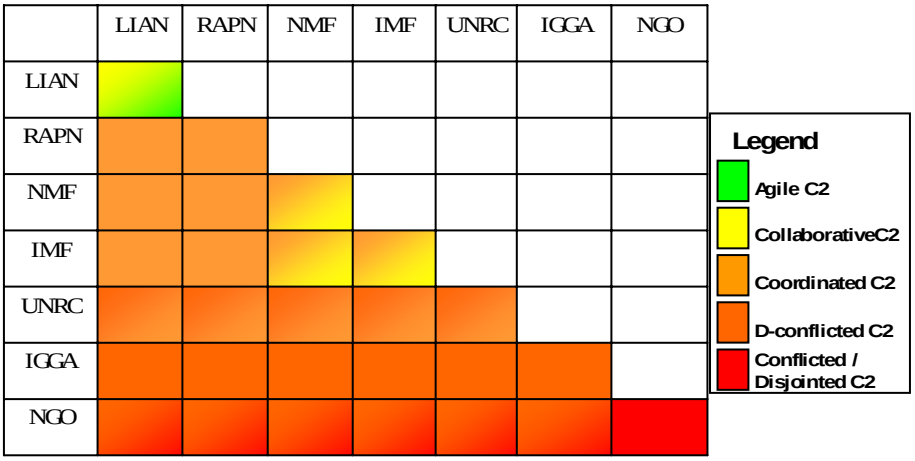

Figure 4: Visualization of C2 Maturity Levels between Interacting Groups of Organizations

It is obvious that in catastrophes like the Indian Ocean Tsunami effective aid can only be provided with the support of capable international NGOs. For the Tsunami relief phase interactions with and between these international NGOs are assessed as conflicted (see bottom line in Figure 4). Given that they have to bear the brunt of the relief operations, their C2 ML is crucial for the effectiveness of the entire operation. The four recommendations listed above do not imply to establish a central coordinating institution to manage such operations. Rather the second recommendation suggests that increased individual capacities and improved linkages between organizations will provide the basis to develop a coherent international disaster response system. And, most importantly, recommendation one implies that NGOs must subordinate their intents to the intents of local communities which implies a collaborative C2 approach.
Presumably because of the magnitude of the catastrophe and the associated problems with coordinating through a central authority embedded in a superior institution, only a self-organizing, collaborative C2 approach seems to provide the capability to deal with the enormous number of involved organizations in disasters of this extent. In terms of ML this

means, that the current state of De-conflicted C2 has to be replaced at least by Collaborative C2 to cope efficiently with the high complexity of such catastrophes.

Elbe Flood 2002

The Elbe Flood of August 2002 is considered one of the worst natural disasters in German history. Heavy rainfall lasting for ten days without interruption[11] led to an immense rise of water levels of the many rivers in the Erzgebirge that feed the Elbe flooding large parts of Saxony – a state located in the eastern part of Germany. 20 people died and about 80,000 had to be evacuated. The damage was estimated by the Saxon authorities to amount to 6.2 billion €. The capital Dresden suffered damage on the order of 340 Million Euros. 61 schools were severely damaged and 20 hospitals were completely evacuated. In Dresden 100 % of the hospital capacities were afflicted and had to be evacuated.

Sequence of Events

To better understand the development of the flood it is necessary to have some knowledge of the topography of Saxony (see Figure 5). Located in the South of Saxony, the Erzgebirge is a long stretch of mountains with many small rivers and creeks. North of the Erzgebirge, the terrain slopes down gently to become rather flat in the North of Saxony. The rivers in the Erzgebirge are connected with larger rivers which run roughly south-east to north-west. The incessant rain caused water levels of the rivers in the Erzgebirge to rise quickly. Rainfall climaxed between August 11 and August 13 measuring up to 500 mm or 500 litres per m² (Malitz, 2005; Report SMUL, 2003).

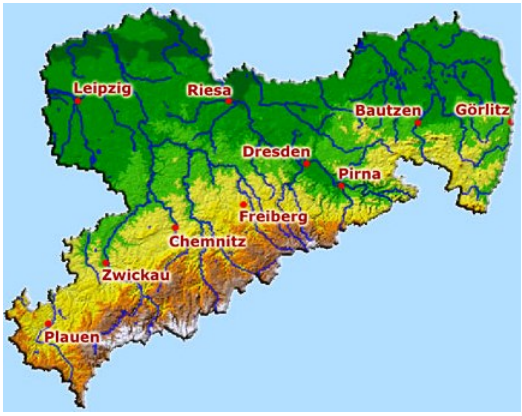

Figure 5: Saxony's Topography

Such an amount of water was beyond what the small rivers in the Erzgebirge could accommodate. They flooded and destroyed a numerous villages and small towns. Fed by rain no more absorbed by the mountain soil, the water levels of larger rivers in Saxony rose dramatically and many dikes broke. The Elbe's level reached an unprecedented and unexpected 9.40 meters. After all, this was one meter above the highest level ever registered before (1845).

[11] The reason for this was a Vb (five b) weather condition which is well known to bring huge amounts of rainfall causing during history most of the heavy floods recorded in Germany. Van Bebber (1841 – 1909) introduced this classification to describe several typical routes of low pressure areas. (Schumann, 2004)

The German Disaster Response System

In Germany, disaster response distinguishes three steps. 1) preparations to control and reduce effects of a disaster; 2) management of disaster response operations; 3) repair of critical damage caused by disasters. State laws define a disaster as an occurrence that endangers people's life and health and/or their supply with vital goods or services on a large scale, the environment or economic goods to a degree that effective protection and aid requires the engagement of governmental and non-governmental organisations under the leadership of a dedicated disaster response organisation (SächsBRKG, 2004).
Like in many other Western Nations, subsidiarity is the basic principle for organizing disaster response in Germany. Local authorities are responsible first, followed by community, district, regional, state and federal authorities. Responsibilities are assigned through a set of laws the most important of which are the *Grundgesetz* (constitutional law) and the *Zivilschutzgesetz* (civil protection law) of the Federal Republic of Germany. Accordingly, federal authorities are responsible only for special training and financial support of state authorities, not for coordination or control of response resources in disaster response operations including the German Armed Forces, Federal Police, Federal Border Guard and the so-called Technical Aid Organization (THW[12]). Coordination of resources in a disaster management operation is the responsibility of a disaster management staff established by the department of interior of the respective state. The federal authorities also finance equipment for fire and ABC-protection, medical and care services. Its allocation is decided at state level. The Federal Department of the Interior proposes accreditation of the five most important German NGOs (German Red Cross, *Malteser Hilfsdienst, Johanniter-Unfall-Hilfe, Deutsche Lebensrettungsgemeinschaft* and *Arbeiter-Samariter-Bund*), but they become accredited by state authorities which are also responsible for tasking NGOs in a disaster. Figure 6 depicts these relationships.

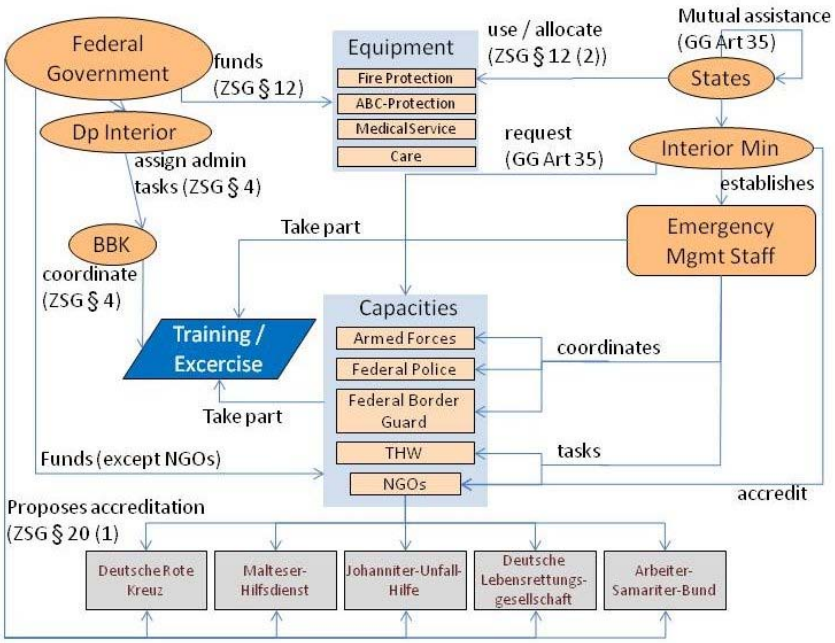

Figure 6: The German Disaster Response System

If state authorities are not able to control a disaster with their available resources – state police, fire protection forces, and NGOs – they may request support from federal government

[12] The THW is a disaster relief organization of the Federal Government (Ministry of the Interior).

authorities. Community authorities – which have no legal responsibility for disaster management – are all days responsible for operating their own fire fighting capabilities. The first level responsible for disaster management is the district authority. Thus, the Elbe flood response involved a shift of command from the community level to the district level for 70 % of the personnel of Saxon disaster response organizations (3,800 police, 4,000 NGOs, *20,000 fire fighters*).
Table 3 summarizes for the personnel deployed by the respective organizations to support the Elbe Flood response operations (von Kirchbach et al. 2002). While the high number of unorganized volunteers was both impressive and remarkable it also presented a problem. Human resources deployed by the Federal authorities included 15,500 military and 2,200 police personnel and 1,835 technical specialists of THW. The majority of the soldiers served with a division stationed in Saxony.
The large number of participating entities and organizations and, more importantly, the high number of personnel increased the complexity of the situation as discussed in the following.

Participanting Organizations	From without Saxony	From within Saxony
German Armed Forces	15,500 (179 units) 15,500 soldiers	
Federal Border Police	2,200	
THW	2,835	
Police		1,600 – 4,000
Fire Fighters		20,000 – 23,000
NGOs (five accredited)	6,352	4,076
Unorganized volunteers	6,661	16,893
Total	33,548	42,569 – 47969

Table 3: Personnel deployed to support ELBE Flood Distaster Response

Assessment of Complexity

As for the Tsunami case study, the complexity of the Elbe Flood relief operations is assessed based on the six dimensions of complexity defined above.

Connectivity and Interdependence

In addition to the key players listed in Table 3, many more small and also a few international organizations were involved. However, the contingents provided by them were very rather small, operating special equipment that was necessary in the early phases of reconstruction (von Kirchbach, et al., 2002). The size of entities formed by the participating organizations differed considerably. Connectivity, i.e. connections and interactions between entities, and interdependence emerged largely during operations as required via both the disaster management staff and/or the locally responsible leadership. Considering the relatively small number of organizations involved and the limited variety of their entities, both connectivity and interdependency are assessed as low at the overall level of the state of Saxony and medium at local levels of directly affected communities.

Co-evolution

Co-evolution in the sense of a dynamic process of mutual change of systems or entities participating and their environment is judged to be a relatively weak indicator of the complexity of disaster response operations in case of the Elbe Flood. For one thing, technical

deficiencies of communication notwithstanding, C2 processes were considered as adequate. For the other, major changes resulted from the recommendations of the commission – chaired by former Chief of Staff of the Bundeswehr, General von Kirchbach – which was tasked by the state of Saxony to analyse the operation, compile a list of lessons learned, and propose changes to improve the effectiveness of all aspects of the disaster response system. As a consequence, the three formerly stand-alone laws on fire protection, rescue services, and disaster response were integrated into a common law accounting for the operational interdependencies of the three functions and mandating joint training and exercise. In addition, zoning laws were amended to limit new construction in potential flood areas. During the operation, the relatively large number (more than 22,000) of unorganized volunteers represented the most problematic aspect. To some degree, the problem was addressed ad hoc by limiting the volunteers' freedom of movement in the disaster area and integrating them into tasks performed by the participating organizations.

Far from Equilibrium

Having been "pushed away from equilibrium" is key to the definition of a disaster in German emergency legislation. The degree to which the Elbe Flood is to be classified as a disruptive change, this dimension of complexity may be reflected by the numbers in Table 4 taken from the Saxonian government Report SMUL (2003).

	Total	Mio €
Damage to housing in total	22,652	1,706
Damage to local infrastructure		1,287
Damage to state infrastructure		928
Damage to commercial & industrial entities	11,961 directly affected	1,420
Total Damage % of GDP	7	6,200

Table 4: Damage caused by the Elbe flood

These numbers indicate that the Elbe Flood caused a more or less severe disturbance of Saxony's equilibrium mainly at local levels. The total material damage caused by the flood amounts to about seven percent of Saxony's GDP – fairly modest in comparison to the Indian Ocean Tsunami, the comparative small area affected by the Elbe Flood notwithstanding. Thus, there is no reason to assume that the original equilibrium cannot be restored. In fact, at this time most of the damaged communities have been restored to their *status-quo-ante*. The population loss – not listed in Table 4 – was small (20).

Space of possibilities

Variety is crucial for a complex system to be capable of adaptation. In hierarchical systems variety is limited as it serves as a means for complexity reduction. However, despite its organisational structure and the associated limitations of the variety of its option space the performance of German disaster response system in managing the Elbe Flood disaster was satisfactory. The legislated changes for improving effectiveness through joint training and exercise are essentially meant to increase the space of possibilities for action in future disasters on a scale and complexity similar to the Elbe Flood.

Self-organisation

In conjunction with its hierarchical structure, laws and regulations leave the German disaster response system little room for self-organisation. Nevertheless, there were several examples

of self-organisation when local authorities coordinated their actions as communication with superior district and state authorities was cut off (von Kirchbach, et al., 2002). However these examples are exceptions.

Composite Complexity

The qualitative assessment of the complexity of the Elbe Flood operations related to each of the six selected complexity dimensions is summarized in Table 5.

Complexity Dimensions		Complexity Level		
		Low	Medium	High
Connectivity	Overall	X		
	Local		X	
Interdependence	Overall	X		
	Local		X	
Co-evolution		X		
Far-from-equilibrium	Overall	X		
	Local			X
Space-of-possibilities		X		
Self-organisation		X		

Table 5: Assessment of Complexity Dimensions in Elbe Flood Response

Except for the dimensions “Far-from Equilibrium”, “Connectivity“, and “Interdependence”, complexity was generally categorized as having been low. For the dimension “Far-from Equilibrium” it is judged to have been relatively high at the local level where village infrastructures and communications with the outside world were destroyed, and low overall considering the degree to which the State of Saxony as a whole was affected. To some degree Connectivity and Interdependence emerged ad hoc as situations requiring local collaboration arose. Nevertheless, the composite complexity of the endeavour is considered as low, especially when comparing size, scope, and severity of the event with the Indian Ocean Tsunami.

It should be noted that in addition to the consequences of the Elbe Flood, the complexity ratings also account for the rather mature level of disaster response by the State of Saxony which enabled it to fairly quickly return to an equilibrium that largely preserved the social status-quo-ante, extensive and severe local damage notwithstanding. Thus, however the complexity of the Elbe Flood endeavour may be rated, the response organization’s capability was mature enough to cope with it.

Assessment of C2 Maturity

As described above, at the heart of the German disaster response system is a disaster management staff convened by the ministry of the interior of the respective state when threatened or hit by a disaster. In part, this staff is a standing institution – with temporary presence of members of governmental and non-governmental organizations – which supports co-operability by building trust among the mainly hierarchically structured organizations through familiarization of their staff representatives.

In order to support coordinated planning for operations management, the staff is reinforced by liaison officers from all participating organizations in case of an emergency. While the authority to direct the employment of entities deployed by participating organizations shifts to the “incident command” of the respective state interior ministry, command remains within

each of the participating organizations. Thus, the C2 maturity level of the German disaster response system satisfies the criteria for "Coordinated C2" as defined by the maturity model (N2C2M2), albeit leaving authorities on all levels sufficient freedom thus providing for requisite variety to deal with emerging problems in an un-bureaucratic and responsive manner (see von Kirchbach, et al., (2002), pp. 120, 191, 202).

Summary

Elbe Flood case study suggests that "Coordinated C2" of not too large a number (< 10) of more or less hierarchically structured organizations is appropriate for effectively managing disasters of a magnitude and severity comparable to the Elbe Flood disaster given that authorities at lower levels in hierarchies and deployed entities are authorized to decide ad hoc how to meet unforeseen problems emerging in the field. Such an allocation of decision rights is a longstanding practice in the German military is known as *Auftragstaktik*. Notwithstanding *Auftragstaktik*, however, this is not to say that the Elbe Flood operations could not have been managed more effectively and efficiently if C2 would have been more mature. Even though not explicitly stated, the changes proposed by the von Kirchbach commission, to improve coordination and cooperation of the organizations involved through joint training and exercises, imply improved collaboration within the coordinated C2 approach practiced by Elbe Flood disaster management. Thus, if implemented the recommendations would be a first practical step toward increasing the maturity of C2 for emergency management in Germany.

Comparison of Case Study Findings and Insights

In conclusion, a comparison of the findings from both case studies is attempted to provide some insights regarding relationships between the maturity of C2 approaches to and the effectiveness and efficiency of emergency response operations of different complexity. To this end Table 6 presents an overall qualitative assessment of the respective variables based on the evaluation of relevant facts retrieved from various documentations on the two case studies. It should be kept in mind, however, that a viable assessment of this kind is the more difficult to make the higher the complexity of the cases studied. Therefore, the conclusions drawn from comparing the cases of the Elbe Flood and the Indian Ocean Tsunami must be considered as preliminary.

Case	Tsunami 2004	Elbe Flood 2002
Complexity	very high	low - medium
C2 Maturity	disjointed – de-conflicted	co-ordinated
Effectiveness	low	high
Efficiency	very low	medium

Table 6: Overall Assessment of Emergency Response Cases

The fact that the effectiveness of the Elbe Flood disaster management operations is generally considered as having been high does not mean, however, that a coordinated C2 approach would be sufficient for operations of higher complexity, not to mention the unparalleled

complexity of the international response to Indian Ocean Tsunami, even if the deficiencies diagnosed by the Kirchbach commission were implemented.[13]
Apparently designed for coordination of international aid in natural disasters on a limited scale (such as, e.g. earthquakes), the structure of C2 approach of the United Nations is rather similar to that of the German disaster management organization. The structure of both reflects a coordinated C2 approach.[14] However, because of the magnitude of the Tsunami catastrophe (affecting 14 countries around the Indian Ocean) and the extent and severity of damage that it caused on one hand, and the unprecedented number and variety of organizations and entities involved in the international response on the other, the coordination capabilities of the UN Disaster Assessment and Coordination (UNDAC) teams dispatched to the countries hardest hit were quickly overwhelmed and the coordinated C2 approach gave way to disjointed C2 in the early phases of the international relief operations maturing eventually to de-conflicted C2 in some instances.
This assessment is supported by a recommendation put forward in the TEC report (Telford & Cosgrave, 2006) for the re-organization of international aid, that "*all actors should strive to increase their disaster response capacities and to improve the linkages and coherence between themselves and other actors in the international disaster response system, including those from the affected countries themselves*". For highly complex disasters on the scale of the Indian Ocean Tsunami this implies that the UN's current centralized coordinated C2 be replaced by a more mature coordinated, if not collaborative C2 approach as implied by another recommendation of the TEC report that "*The international humanitarian community needs a fundamental reorientation from supplying aid to supporting and facilitating communities' own relief and recovery priorities"* (Telford & Cosgrave, 2006).

The findings from both case studies support the hypothesis of requisite maturity of C2 in that the lower complexity of the Elbe Food's operational environment compared to the Tsunami's permitted a more efficient use of available resources even though the C2 approaches for managing the relief operations were structurally quite similar in both cases, at least initially. In other word's as complexity of the operational environment increases so must C2 maturity.

[13]Several press reports on German Provincial Reconstruction Teams in Afghanistan suggest that the implementation of a comprehensive "whole-of-government" approach for the German PRT operations implies a degree of complexity that overtaxes the C2 approach involving the coordination of a variety of entities each controlled by representatives of one of four federal government ministries: Foreign Affairs, Interior, Economic Cooperation and Development, and Defense. The PRT's effectiveness suffers because - due to different organisational cultures of the ministries involved - shared intent is frequently missing and information sharing limited causing adverse cross-impacts of effects from entity actions (See e.g. Citha, 2007, p. 2).

[14] International relief is coordinated by the UN Office for the Coordination of Humanitarian Affairs (OCHA) through the Interagency Standing Committee (IASC) chaired by the UN Relief Coordinator (ERC). IASC compares to the (partially) standing emergency management staff of the Ministry of the Interior of the affected state.

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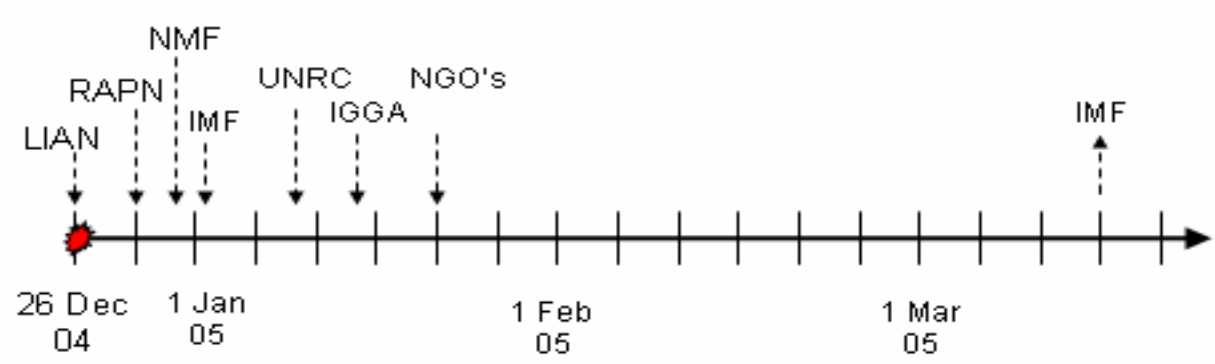
Annex A

Major Agencies and Organizations engaged in the Indian Ocean Tsunami Response

No exact numbers are available of the number of total number of Agencies and Organizations engaged in the Indian Ocean Tsunami response throughout the affected region, including national international non-government organizations (NGO) and privately organized groups. However, at certain points in time it might well have approached more than one thousand considering the numbers quoted in the TEC Synthesis Report for Indonesia and India alone. More than 380 humanitarian organizations had registered in Aceh by the end of March 2005, and 124 international and 430 local NGOs by December 2005, in addition to numerous UN and foreign government aid agencies. 150 NGOs were registered, and presumably the same number unregistered, in the Nagapattinam District of India.
There were se seven principal categories of responding agencies and organisations:

- LIAN: Local Individuals, Agencies, NGOs
- RAPN: Regional and Provincial Agencies, National NGOs
- NMF: National Military Forces
- IMF: International Military Forces
- UNRC: United Nations and Red Cross/Red Crescent
- IGGA: International Governments and Governmental Agencies:
- NGO: International Non Governmental Organizations

Their (approximate) arrival times in Aceh were as follows:



By agreement with the respective governments, international military presence in Aceh ended by 26 March

LIAN
Local Individuals
Relatives, Neighbours
Local Economy
Local Agencies/Admin
Local NGOs

RAPN
Regional Agencies; Admin
Provincial Agencies; Admin
Regional Governmental Agencies
National Governments
National NGOs (176)
National enterprises
National Individuals « willing to help »

NMF
National Military Forces of India, Indonesia, Malaysia, Sri Lanka

IMF
International Military Forces from
Australia, Austria, Bangladesh, Brunai, Canada, France, GBR, Germany, Japan, South Korea, New Zealand, Norway, Pakistan, Singapore, Switzerland, Thailand, USA

UNRC
United Nations and Red Cross/Red Crescent:
UN General Assembly
Office of the UN Recovery Coordinator for Aceh and Nias
UN Office for the Coordination of Humanitarian Affairs
UN Development program
UN Children's Fund
UN High Commissioner for Refugees
UN Human Settlements Program
UN Industrial Development Organization
UN Information Centre
UN UN Population Fund
UN Resident Coordinator
UN Economic and Social Council
UN Food and Agriculture Organization
UN World Food Program
World Bank in Indonesia
World Health Organization
Asia Development Bank
International Civil Defence Directory
International Committee of the Red Cross
International Federation of Red Cross and Red Crescent Societies
International Labour

IGGA
International Governments and Governmental Agencies:
Government of:
Australia
Japan
Switzerland
United Arab Emirates
United States Agency for International Development
United States Department of State

NGO
Non Governmental Organizations:
International Network of Action Against Hunger
Agency for Technical Cooperation and Development
Action by Churches Together International
American Jewish World Service
AmeriCares Foundation
Christian Aid
Church World Service
Disaster Tracking Recovery Assistance Centre
Direct Relief International
Development and Peace
GOAL
Groots International
Habitat for Humanity International
International Commission of Jurists
International Medical Corps
International Rescue Committee
JEN
Malteser International
Mennonite Central Committee
Mercy Corps
Medair
Medical Emergency Relief International
Muslim Aid
People in Need Foundation
Presbyterian World Service and Development
Singapore International Foundation
SOS-Kinderdorf International
Swayam Shikshan Prayog
International Federation Terre des homes
Tsunami Response Watch
The United Methodist Committee on Relief
World Vision
Interagency Standing Committee
International Organization for Migration

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