

Modelling a Humanitarian Supply Chain using the Structured Analysis and Design Technique (SADT)

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Abstract

Conflicts since the end of the Cold War have seen military and civilian assets deployed side by side as part of an overall UN mandated solution. In order to visually present the integrated nature of humanitarian supply chains 'Structured Analysis and Design Technique' (SADT) has been used. SADT was chosen as it provides a robust structured method to model hierarchical systems and for this research it provides an opportunity to define and analyse the coordination and co-operation in terms of the humanitarian supply chain process, humanitarian supply chain activities and the actors involved. This research demonstrates that the visualisation facility that SADT provides not only helps in understanding the interrelationships between the actors and stakeholders involved in a humanitarian supply chain but also to some extent explains how a more effective co-ordination of humanitarian operations by military and civilian organisations involved in a complex emergency can be achieved.

Keywords: Humanitarian Aid, Models, Supply Chain Management, Military, Structured Analysis and Design Technique (SADT), Visualisation,

Introduction

No one...has a monopoly on humanitarian work. The military should not just assist relief and aid organisations by protecting convoys but should become directly involved in providing aid. (Ziegler and Handley, 2004:9)

Humanitarian aid involves a growing and complex plethora of actors and agencies from the civil, business and military sectors (Olorunfoba & Gray 2006). As identified by Thomas and Kopczak, (2005) humanitarian logistics, as well as business logistics, encompasses a range of activities including preparedness, planning, procurement, transport, warehousing, tracking and tracing and customs clearance (see Figure 1). This presupposes a sophisticated coordination of activities to carry out the primary mission of humanitarian aid – delivery of product and/or service to the end user, whose immediate and longer term survival may depend upon efficient completion of logistics and supply chain operational activity up to and including the crucial 'last fifty metres'.



Figure

1: Fritz Institute Humanitarian Supply Chain (Source: Thomas, 2004)

The current empirical literature for humanitarian logistics emphasises response from post-event evaluation, rather than from detailed pre-planning. Response may be a successful tactic in a controllable emergency scenario requiring limited flexibility and offering achievable solutions. In a humanitarian crisis where complexity reigns an alternative approach is called for. *It requires the components of integration, collaboration and intensity of focus for systems, people and aligned organisations from a multiplicity of backgrounds grounded in instinctive flexibility and adaptability to rapid change coming from the confidence engendered by incisive training and development.* **REWORK**

It might be argued that there is no common ground between business, military and humanitarian logistics and supply chain management because of sector-specific conflicting tensions in mission objectives (i.e. customer-context -objectives). The underpinning hypothesis of this paper is that there is no fundamental difference, principles and practices from each are adaptable and interchangeable with the fundamental

nature of logistics, which is shifting product or service in response to customer need. The triad of business, military and humanitarian logistics superficially display compositions and responses as independent supply chain activities, with a number of distinct and independent actors with differing logistics management styles (Grant 2004). Except for context and objectives, there is a subtle connection, the commonality of logistics and the supply chain as a phenomenon with singular principles and practices (Harrison & van Hoek 2005:6-13; Chopra & Meindl 2007:9-16; Grant et al 2006:3-29). This singularity offers opportunity for the incorporation of best practice training in collaborative techniques and concepts into humanitarian logistics supply chain management (HLSCM) development.

Recently a wide variety of government, military, academic and business literature has ranged across humanitarian logistics and supply chain management pre and post operations activities. No specific research has been undertaken to examine if there are common cause and effect principles across the business, military and humanitarian triad which may in turn offer to assist in developing an improved common global training and operational application template for HLSCM personnel. Outside the world of business, logisticians in many other fields face the challenge of successfully managing the transition between steady state and surge situations (Tatham & Kovács, 2007). This is particularly true for humanitarian logisticians preparing and executing their organisations' response to a rapid onset disaster where the price of failure can be counted in lives rather than lost profits (Tatham & Kovács, 2007).

Methodology

This paper is intended to contribute to the humanitarian logistics and supply chain operations literature, and also to encourage further debate around themes introduced in the strategic evaluation of military, non-military and composite emergency relief logistics (Pettit & Beresford 2005), the comparison of humanitarian and commercial supply chains (Beamon 2004), and the co-ordination of humanitarian operations (Rietjens et al 2007). The literature review, although of necessity selective, enabled identification of a clear gap between practice (functionality) and empiric evaluation and preparedness (strategy) for HLSCM which can activate the whole scenario of risk-related failures (Table 1; figure 2). Solutions proposed in the literature reviewed centre upon variants adapted from lean and agile conceptual approaches to logistics and supply chain management, which have been applied in business and military logistics operations and continue to be so applied, with some successes, but also some failures. Lean and agile concepts have a common logistics systemic specificity requiring collaboration throughout and between the supply chain tiers and actors at all levels and positions of responsibility, together with innovative adaptable response to unpredictable demand variability. Where collaboration is not developed sufficiently to offer a robust and responsive logistics system, product or service delivery failure is inevitable, this is a given to any commercial or military logistics professional. Evidence of the propensity to HLSCM failure from inattention to supply chain relationships has been supported by the numerous well publicised humanitarian logistics operational failures of recent years, in which lack of coordination (i.e. collaboration) between actors has played a major role. In part this appears to be attributable to a silo-functional approach to HLSCM by aid organisations and their personnel, an approach which has been, or is being, rapidly abandoned in the business and military logistics sectors.

The author's research is centred on a case study approach. The case study is a research strategy, which focuses on understanding the dynamics present within single settings (Eisenhart, 1989). Yin (1994), proposed a technical definition as follows: **A case study is an empirical enquiry that:**

- Investigates a contemporary phenomenon within a real-life context;
- Where the boundaries between phenomenon and context are not clear; and
- In which multiple sources of evidence are used.

The primary motivation for the research was the need to examine the effect of integrated logistics system operating in the region, and their impact on responsive disaster logistics management. The main construct behind the research was that of "disaster logistics responsiveness". One of the main hypotheses derived from the construct was that, what are the determinants of a responsive logistics system during a disaster?

The choice of research design and methodology are closely linked. The research design process will involve the outlining of strategies for performing the research and the use of the most appropriate type of research methods. Analysis and conclusions will be dealt with in the following sections. In this research, the author's main research strategy is to use the "triangulation" technique within his case study.

Triangulation of research methods lends greater empirical support to the theory in question where both qualitative and quantitative methods are used appropriately (Gubba and Lincoln, 1994: 105-117). In this case study, the author used three types of triangulation techniques. The first was “*investigator*” triangulation (i.e. by employing multiple observers for the same phenomenon) as the author collected data from users of the NGOs; victims, policy makers, and local and international volunteers. This data triangulation has been done in six affected provinces (Phuket, Phang Nga, Krabi, Ranong, Trang, and Satun) of southern Thailand. Since Thailand was the main focus of the research, the emphasis on Thai policy makers, transport/logistics service providers, workers/volunteers and victims was a prerequisite for the successful completion of the study. Policy makers, transport/logistics service providers, workers/volunteers and victims in the neighbouring countries were not considered part of the research.

The second triangulation technique was “*theory*” triangulation (i.e. by approaching empirical materials from various perspectives, theoretical framework and interpretations). The third triangulation technique was “*data*” triangulation. The author collected data from government sources, newspapers, magazine articles, websites, interview data from the NGOs who participated in relief work, policy makers, experienced people who were either victims or volunteers, etc. This data triangulation has been done in Phuket, Phang Nga, Krabi, Ranong, Trang, and Satun (see Table 1).

The author combined different theories in order to try to obtain a fuller picture of the study. The methods of data collection and interpretation used in this case study were: 1. Questionnaire (structured interviews); 2. Unstructured interviews; 3. Procedures used in handling the disaster. In the research, more than 120 respondents were interviewed between January and December 2005. Some respondents were interviewed individually and some were interviewed in focus groups of 4 or 5 persons depending of their availability. A confidence index was used to appraise ‘risk analysis’ in this study, which was derived from the field of political science, especially political instability methodology. Qualitative predictive research in political instability focuses upon intuition, judgment and Delphi forecasting (Andriole and Hopple, 1983: 75-97). Intuitive qualitative forecasting is central to a systematic analysis.

The explorative nature of this project and the complexity of the research problems as well as our research objects demand a holistic perspective and suggests empirical case studies, which are especially well suited for obtaining necessary depth of exploring and developing understanding for under-researched areas (Ellram 1996, Yin 2003). Based on systematic combining (Dubois & Gadde 2002), our case set studies develop through interplay between the real world and a model world. Our preliminary theoretical framework is confronted with reality in order to identify new questions and needs for other concepts from the model world. The work in the model world then gives another of questions to reality, leading to new theoretical questions. Providing a starting point both for research problems and a common knowledge base for all project participants, our cases have been chosen in a systematic way in order to cover variability of the dimensions of interest. We will undertake three single case studies (Yin 2003) that vary with regards to degree of centralization, type of disasters and coordination, e.g. in terms of civilian/military cooperation, and use of coordination mechanisms: IFRC regional logistics concept for handling sudden-onset natural disasters, United Nations Joint Logistics Centre (UNJLC) and Military Peacekeeping Operations (PKO). Each of these is detailed below.

With regards to data collection, each case study will be based on a multitude of sources, including technical artefacts (i.e. physical structures, product catalogues and ICT systems), systematic interviews, documents and archival material, possibly cross sectional data and time series data. In order to ensure reliability, a case study protocol including semi-structured interview guides will be developed. A case study database for inclusion of notes from each interview, detailed write-up of each case and other documentation, will be developed. Multiple data sources will be used to ensure construct validity, as will a pre-structured case outline for data analysis (Ellram 1996, Yin 2003).

Modelling

The Asian tsunami of 2004 placed humanitarian aid provision under greater stresses than ever before with the sheer scale of the disaster leaving more than 220,000 dead. Aid distribution had to be co-ordinated on an unprecedented scale amongst a number of Governments and a wide range of NGOs, UN bodies, ICRC and Military players (Marlowe, 2005). During that disaster the function of logistics in effective relief became familiar to the public. (Perry, 2007) As a consequence of the Tsunami in 2004 and in prior logistics research (van Wassenhove 2006), preparedness and responsiveness were shown to be connected.

Logistics problems arising from disasters, e.g., drought and earthquakes, in spite of their critical importance have, especially in the area of relief distribution, elicited only a limited amount of related research (Sheu, 2007). Whereas the literature traditionally has focused on improving efficiency and reducing costs, i.e. on the leanness of supply chains (Lee 2004), the current trend within commercial logistics is towards more innovative and responsive, i.e. agile supply chains that operate in highly dynamic environments (e.g. Towill and Christopher 2002). A major question is whether traditional models, describing topics as supply chain modelling and optimisation (Lee et al. 2004, Svensson 2003), performance measurement (Bagchi et al. 2005, Beamon 1999), supply chain processes (Croxtton et al. 2001, Lambert et al. 1998), portfolio models (Fisher 1997), and collaboration and integration within and across company boundaries (Barratt 2004, Fawcett and Magnan 2002, Min et al. 2005), work for temporary and non-commercial systems typical for humanitarian logistics. Research on 'event' or 'project' logistics such as humanitarian logistics is attracting attention, but is still scant. **Concerning coordination and integration the question of centralized versus decentralized structures and decision making has been of particular interest in prior research, for example regarding sourcing and procurement (e.g. Stock and Lambert 2001, Gutierrez et al. 2003).** REWORK Coordination and linkages within and between temporary solutions and more permanent networks have been discussed in research on logistics in the construction sector in particular (see e.g. Dubois and Gadde 2002).

In view of the complexity and difficulty in solving the emergency logistics distribution problem within a single model, there is now a tendency of decomposing the original problem into related sub-problems, which are then solved within the same decision scheme. An example is the two-level hierarchical decomposition approach given in Barbarosoglu et al. (2002) in respect of the problem of helicopter mission planning during a disaster relief operation. Another example is a study by Ozdamar et al. (2004) which interestingly combines the vehicle routing problem with the relief distribution process, regarding vehicles as commodities and splitting the complex emergency logistics distribution problem into two multi-commodity network sub-problems, and then solving them by means of Lagrangean relaxation (Daskin, M.S., 1995). Different optimization methods and systems dynamics models have also been examined, for example; Hybrid fuzzy clustering optimization (e.g. Sheu, 2007a), combinatorial optimization in terms of Vehicle Routing Problem (VRP) (e.g. Yi and Özdamar, 2007), real-time decision-making systems (ARES) (Brown and Vassiliou, 1993) and simulation by Rockwell Software's Arena v. 80 (e.g. Beamon and Kotleba, 2006).

Humanitarian relief supply chains can be seen as a systems exercise, involving the integration and co-ordination of widely scattered groups of specialists (Stevenson, 1994). There are many different types of logistic programmes and activities that have to be planned and implemented around the specific catastrophe that has occurred, but forward planning can be initiated through the use of an accepted template for disaster planning (Carter, 1991).

Although many articles have been written from a systems perspective, Structured Analysis and Design Technique (SADT) has not been included in humanitarian logistics. From an examination of the literature no articles were found where SADT had been used in modelling particularly aimed for humanitarian logistics. The main aim of this paper is to create a model that describes the actor interrelationships in a relief supply chain using SADT.

REWORK

The first created model presents the interrelationships of actors during the immediate response phase in terms of main flows: information, material and financial flows. The second modelling focuses on the material flow and was performed by using XXXX is a very useful tool that can be used to simulate discrete dynamic systems and consists of flows, stocks and variables that may

vary over time. (Kirkwood, 2002) The created systems model illustrates the actors involved and their interrelationships or dependencies, which are modelled as discrete functions.

Coordination in Humanitarian Supply Chains

Central to any relief operation is the establishment and management of an emergency supply chain which is often fragile and volatile. The provision of humanitarian aid and the complex logistics systems which enable that aid to be delivered are more intricate than simply providing disaster relief, for example securing humanitarian aid and protecting the supply chain are important (Byman et al, 2000). Provision of humanitarian aid generally, although not exclusively, takes place in locations where sophisticated logistics techniques are difficult to implement (e.g. major natural disaster or military conflict) and which, therefore require some form of co-ordination between NGOs or between military and NGOs but where there is little agreement on the status of the relationships between them (Pettit and Beresford, 2006). Responses to both natural and man made crises are generally multi-faceted and involve governments, NGO's UN agencies, military bodies and private sector organisations.

In order to be effective, a supply chain in a humanitarian aid operation should be 'owned', that is, responsibility for it should be taken by one of the players in the scenario (Moore and Antill, 2000c). Such a concept would be in line with commercial practice in, and academic theory in supply chain management. Difficulties that arise in the ownership of the supply chain stem from the complexities and difficulties inherent in such operations, such as relationship issues, that impair the smooth operation of the cycle. The aims and objectives of individual agencies are not always conducive to an integrated and co-ordinated effort. Objectives that have become highly politicised at the strategic level can impair the benefits that can be gained from a concerted and co-operative effort among the various players at the operational level. Logistics activities have, until recently, been undertaken in a fragmented and sub-optimised manner and based upon outdated logistics philosophies.

It is possible to identify a generic model of a supply chain that applies in many of the humanitarian aid scenarios. Such a supply chain is usually designed to allow a one-way flow of goods and equipment into the theatre of operations to the places where it is needed the most (Hoff, 1999). The 'actors' in such humanitarian aid scenarios all have differing management styles and administrative structures and whilst the supply chain appears straightforward, the complexities in the relationships that occur, together with incompatible structures and procedures, may conspire against the establishment of effective supply chain strategies.

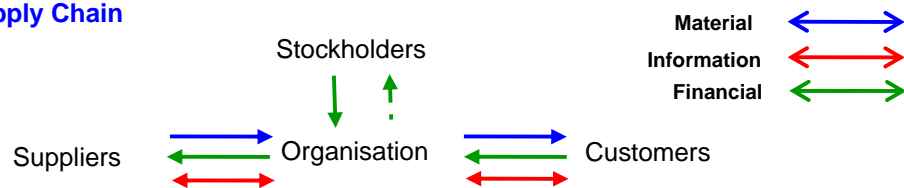
It has also been found that there is a general concern about the way donors distribute their aid, the reactive nature of funding, the unwillingness to fund managerial overheads, the threat to an organisation's freedom of action and the increased pressure for accountability (Molinaro, 2000; Thornton, 2001; Barton, 2000). This is exacerbated by difficulties within the area of UN / NGO co-ordination which are well documented (Molinaro, 2000; de Mello, 2001; Moore and Antill, 2000c; Tomlinson, 2000; Hawley, 2000), with issues such as co-ordination verses control, competition, publicity, conflicts of interest and funding predominant. There have been however, instances of successful co-ordination through logistics and the supply chain. For example, recent operations in Ethiopia have had NGOs and UN agencies using World Food Programme (WFP) aircraft to move goods and equipment around. Nevertheless, agencies are often reluctant to be co-ordinated but there is potential for UNHCR to track and co-ordinate the shipment of goods (Molinaro, 2000). NGOs constitute the main *interface* between the *relief system* and the *beneficiaries* and are almost at the end of the supply chain. The position they hold as the implementers of aid relief can conflict with their role as advocates for such relief (Molinaro, 2000).

There is much debate over the role of the military within the humanitarian context. Within this environment, the military do not seem to participate in any systematic overarching coordinated humanitarian plan and are forced to dabble in the provision of humanitarian assistance in an *ad hoc* manner. There are guidelines, such as the *Guidelines on the Use of Military and Civil Defence Assets in Disaster Relief – Oslo Guidelines* (United Nations, 1994), which set out occasions when the military should engage in humanitarian activities. However, these guidelines "are in fact rarely observed" (Gill et al, 2006:41). The provision of humanitarian assistance by the military continues to generate passionate

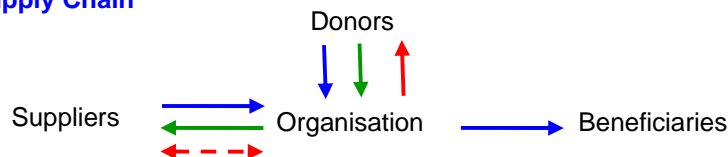
debate, between the military and non military actors (Barry and Jefferys, 2002 and Eriksson 2000), in which there is seldom any meeting of minds.

It appears that the civil-military exchange, or partnership, holds great promise for easing human suffering and restoring stability in ineffective states: the military brings an unmatched ability to provide security, logistical support, and rapid planning, while civilian organizations often offer financial resources, a more complete understanding of the local situation, and expertise in providing relief and beginning the long-term process of state-building. However, as recent experience has repeatedly demonstrated, however, inter-organizational cooperation is far from assured - conflict or an absence of coordination has been more common (George, 2005). Much of the writing on civil-military interaction in peace operations notes this lack of progress (Weiss 1999; Pirnie 1998).

Commercial Supply Chain



Humanitarian Supply Chain



Military Supply Chain



Supply chain professionals in the commercial sector face many of the same issues of trade-offs in performance as a professional working in a disaster relief operation. In business and in disaster relief supply chains, speed is of the essence. Even more striking in parallel are military supply chains, which often face similarly short deployment periods and challenging working environments. Because of these similarities, it is important to understand the underlying principles of commercial and military performance measurement systems when developing a system for disaster relief operations.

Military and Humanitarian Supply Chains

Humanitarian supply chains tend to be unstable, prone to political and military influence, and inefficient due to lack of joint planning and inter-organizational collaboration. They face inadequate logistics infrastructure, along with shifting origins and/or destinations of relief supplies without warning. Furthermore, they have greater issues of safety, involve a great number of stakeholders with various mandates and agendas, and always face the unknown. Donors often request their funds be spent on direct materials and food, and even at a particular disaster location, rather than on crucial but indirect services such as information systems, supply chain management systems, staff training and/or disaster preparedness (Kovács and Spens, 2007; Long and Wood, 1995; Oloruntoba and Gray, 2006; Pettit and Beresford, 2005; Van Wassenhove, 2006).

According to Fritz Institute researchers, few humanitarian relief agencies prioritize the development of logistics and supply chain management. Rather, environmental factors, such as the unpredictability of interruptions and uncertain funding, result in high workforce turnover, fragmented technology, and a lack of knowledge management. Thus, relief operations are less efficient and effective than they could be, and service to beneficiaries is delayed or reduced (Thomas and Kopczak, 2005). Humanitarian assistance supply chains must be flexible and able to respond quickly to unpredictable events. They must also be efficient, and able to operate within limited budgets. In such supply chains, more effective SCM (i.e. improved *customer* service) can be the difference between life and death; and greater efficiency means serving more people in dire need. While "time is money" to the business logistician, time is life to the humanitarian. Thus, there are tremendous opportunities to serve more people in need at lower cost through SCM best practices.

Oloruntoba and Gray (2006) proposed that a typical humanitarian supply chain could follow the sequence in Figure 2. Unlike most business supply chains, the humanitarian aid supply chain is often unstable.

Sometimes, the supply chain breaks down at the receiving end, but it may also be unstable at its origin for two main reasons: politicised donations by governments and the competitive nature of fund-raising from private donors (Oloruntoba and Gray, 2006).



Figure 2; A typical humanitarian supply chain. Source Oloruntoba and Gray, 2006 p.116

Commercial supply chains focus on the final customer as the source of income for the entire chain. However, in humanitarian supply chains the end user (the recipient, the beneficiary or consumer of aid) seldom enters into a commercial transaction and has little control over supplies (Oloruntoba and Gray, 2006). Instead, Oloruntoba and Gray (2006) note that “customer service” or “marketing” of the humanitarian service may need to target the supplier/donor, who has to be convinced that humanitarian action is taking place. For example, there may be greater “humanitarian visibility” in providing food or medicine before basic logistical equipment such as forklifts, although the latter may be necessary for effective delivery of the former (Byman *et al.*, 2000). The nature of most disasters demands an immediate response, hence supply chains need to be designed and deployed at once even though the knowledge of the situation is very limited (Beamon, 2004; Long and Wood, 1995; Tomasini and Van Wassenhove, 2004; Kovács & Spens, 2007). This flexibility and agility is where the military supply chain can excel. The main problem areas of the immediate response phase lie in coordinating supply, the unpredictability of demand and the last mile problem of transporting necessary items to disaster victims (Beamon, 2004; Long and Wood, 1995; Ozdamar *et al.*, 2004; Tomasini and Van Wassenhove, 2004; Kovács & Spens, 2007).

As Pettit and Beresford (2005) acknowledged, military organisations must be able to operate in both conflict and disaster situations and have to adapt to conditions prevailing at any given moment. Consequently, their stance will vary depending on the situation on the ground. This in turn will have an impact on the logistics response. One of the identifiable trends is the increasing need for agility (adaptability) of military logistical support, with less emphasis on buffer stock and more on manoeuvrability (Pettit and Beresford, 2005).

The rationale for moving to a ‘pull’ rather than ‘push’ conceptual approach is that historically HLSCM planning and managing has, by the nature of the operational context influenced a reactive ‘push’ mode in operational planning and application. ‘Push’ approach implies a low grade collaborative logistics network, dominated by an outputs mentality, hence longer reaction times/efficiency and system response degradation.

The inherent requirements to alleviate system degradation are grounded in accurate information, demand forecasting and smoothing of supply chain distortions, ‘customer’ focused, and with a high level of collaborative network efficiency linked to a growing dependency upon ICT. Application of these ‘pull’ type requirements do influence HLSCM systems towards becoming ‘lean’ and particularly ‘agile’ compliant, in the sense of determining and identifying the key processes for efficient system and network management and responsiveness within the humanitarian emergency logistics planning sector. However the current post-operational analyses demonstrate that that compliance will not offer anything other than a conceptually anodyne solution to what are deeply rooted tendencies to HLSCM structural and system failure time after time. The primary cause appears to be a mono-focal emphasis by each tier in the logistics network, when an intense collaborative commitment is vital. SIMPLIFY

No longer do organisations strive to provide services and commodities based on their supply, they seek to tailor made these to their perceived demand; no longer do organisations keep inventory, they seek to hold information of customer requirements; they have shifted from functions to processes, from transactions to relationships (Mangan and Christopher XXXX) they do not have the luxury of having a supply chain which is lethargic and unresponsive. To do their job effectively they need to be agile, responsive and resilient.

Whether a private sector organisation, an NGO, a Military force or a UN agency, the efficient use of supply chain principles provide not only competitive advantage but improvements in humanitarian response. Emergencies, man made or natural, will continue to occur on a regular basis (Thomas and Kopczak, 2005) and logisticians have no control over them though they do have control regarding the quality and efficiency of the humanitarian response. In the humanitarian sector, logistics is seen as a means to an end. Though some have recognised its importance in providing cost effective aid (Thomas and Kopczak, 2005) in reality, logistics continues to be a back room activity since is consistently viewed as : 'the things that happen' between supply and demand. Still, many months after the Indian Ocean tsunami highlighted shortcomings in humanitarian logistics, only a handful of aid agencies have prioritized the creation of high-performing logistics and supply chain operations.

Military forces are seen as a pool of prepared and disciplined source of assistance while the international aid community gears itself for action (Hoff, 1999). However, the involvement of the military in such operations is not without challenges. A balance must be found between supporting the civilian aid agencies to utilise the available military resources, and recognising that military manpower is trained to fight and engage in combat operations. There is quite a wide cultural difference between the civilian aid worker and the soldier (Hoff, 1999; Whitman, 2001).

From this it is possible to develop areas of 'mismatch' when seeking to integrate the various players in a holistic manner. This is known as an 'integrating mismatch' and creates areas of weakness within the system of operation. This can be viewed as an obstacle to the co-ordination of the relief supply chain. "There is insufficient direction at the strategic level and little co-operation in terms of training and exercise" (Skeats, 1998). At the core of the problem lies the lack of a strategic multi-agency response as each organisation has its own strategic headquarters to activate the aid process. The initial focus for implementing a co-ordinated multi-agency response could be a combined base logistics centre. Solutions to logistic issues demand long-term relationships based on trust and mutual understanding enhanced by joint training and exercises. There is also room for the expansion of education, which could cover a wide range of topics including culture, law, the characteristics and organisation of NGOs and UN Agencies and the processes of in-theatre operational logistics (Heaslip, 2007).

Notwithstanding these challenges, there are considerable potential benefits of using the armed forces to provide, or assist in the provision of, logistic support to humanitarian aid and disaster relief operations. The armed forces can bring considerable expertise and professionalism in undertaking logistically challenging roles. They can bring a task focus that is inculcated in their modus operandi, which is rarely matched by civilian aid agencies. The essential and expensive logistic equipment is often readily available for the military; indeed it provides their *raison d'être*. Above all there is within the armed forces a ready pool of experienced logistics personnel who can act swiftly and effectively when tasked.

Structured Analysis and Design Technique (SADT) Methodology

The objective of using SADT is for a complete understanding of the components and their present activities in the port cluster system. Traditionally, PERT/CPM charts are used to manage organisations and work distribution. In the case of functional chart techniques, Flow Charts, HIPO and I-P-O Charts could be used for modelling the sequential processing and physical attributes of a system (Fitzgerald and Fitzgerald, 1987). However, this study focuses particularly on activities in the humanitarian supply chain and the complexity of this requires the use of a better visualisation technique.

Marca and McGowan (1987) divide the range of systems from complex (e.g., the planetary bodies in a solar system) to medium complexity (e.g., the space shuttle) to extremely complex (e.g., molecular interactions in living organisms). The SADT methodology was developed specifically to help people

describe and understand constructed systems that fall into the spectrum of 'medium' complexity. SADT is now one of the most widely used system engineering methods (Marca and McGowan, 1987). SADT is a complete methodology for developing system descriptions, centred on the concepts of system modelling.

The SADT graphic language organizes the natural language in a particular and unique way. It is because of this that SADT can describe complex systems in detail. From the SADT perspective, a model focuses on system activities. Historically, those SADT models that focus on system activities are called "activity models," and those that focus on system data are called "data models." Activity models present system activities in a successively detailed manner, and they define the relationship among those activities through the entities of the system. The complete SADT methodology also includes the construction of multiple models to help in describing a complex system.

With SADT, model building starts with a simple "box and arrow" graphics (Figure 3) showing the function as a box and the interfaces to and from the function as arrows entering or leaving the box. With reference to the relationships or activities in a port cluster within a diagram, the input and output arrows stand for activities, data, and material through, into or from an industry or a firm and the control arrow usually shows a control or data, such as an order. The mechanism arrow relates to the facility or equipment used for an industry activity.

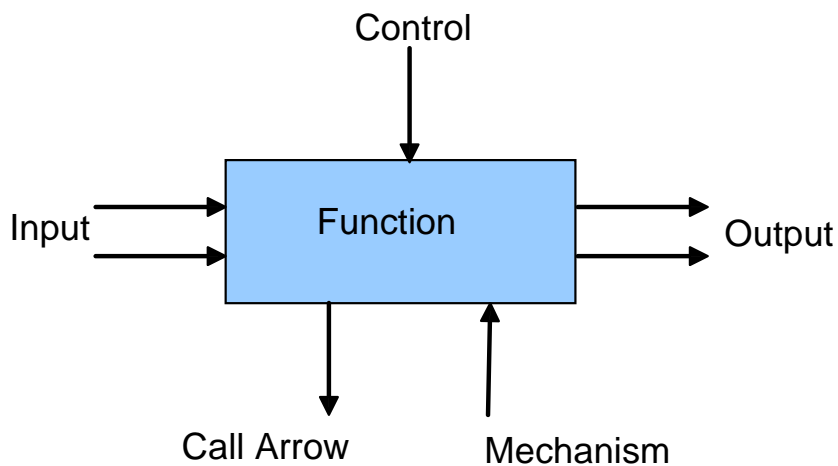


Figure 3 Function Box and Interface Arrows Source: <http://www.idef.com>

The graphical language of the SADT methodology can be considered to be the most important feature, since it produces a modelling method. This involves the structured decomposition shown in Figure 4, i.e., the orderly breaking down and addition of extra detail to a complex system reduced to its constituent parts. Because this method of analysis is top-down, hierarchical and structured, it focuses attention on the important issues, bringing the correct objectives to the foreground as opposed to irrelevant ones which need to be kept in the background. The effect of this in the modelling of a port cluster system becomes obvious since, all the parameters involved in any activity within the model can be accounted for. Simultaneously, the relationship between activities can be identified.

Aguilar-Saven (2004), in a review and categorisation of over 15 different business process modelling techniques, includes an assessment of SADT. SADT, while limited as a 'passive' technique in that it does not allow the user to interact with, and hence change, the models developed, is particularly useful for learning purposes. That is, SADT allows an understanding of what actually goes on in a system, where such knowledge was previously lacking. The hierarchical nature of SADT facilitates the rapid development of business process models. Furthermore, by its very logic of linking functions in the usual left to right manner, the sequencing of activities is identified and hence the process is visualised (Aguilar-Saven, 2004).

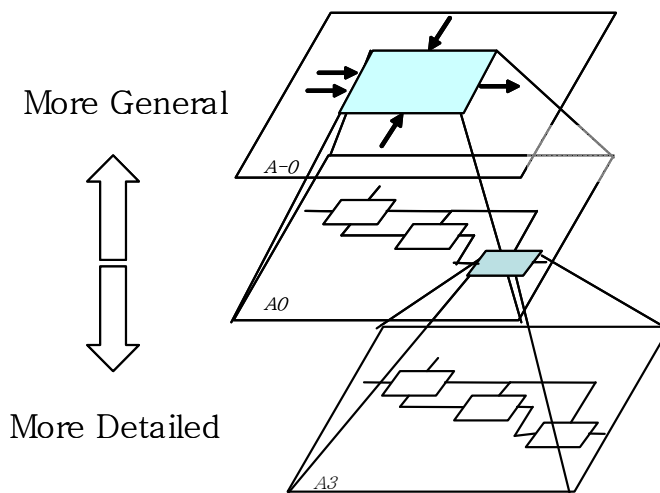


Figure 4 Hierarchy and Structured decomposition of SADT
 Source: Modified from <http://www.idef.com> by authors

Proposed Framework for Integrated Supply Chain

Humanitarian operations by military organisations in peace support missions are, in view of the great variety of needs and stakeholders in a complex emergency, considered as operations with considerable uncertainty (Rietjens *et al*, 2007). The armed forces (i.e. land, naval and air forces) of contributing nations in peace support missions are unique by virtue of the fact that the UN or some other international organization (e.g. NATO, WEU) has authorized them to implement the will of the international community (Rietjens *et al*, 2007). Challenges in respect of co-ordination and integration will need to be met and overcome by the various actors on the stage in order to ensure that the holistic view of supply chain management can prevail in order to improve performance in respect of logistics in humanitarian, disaster relief and complex emergency situations (Moore and Antill, 2002). The input of the model is the onset of a complex emergency. In Ireland, a triple lock mechanism is required before military personnel can be deployed on peace support operations to assist in complex emergencies; initially, the government decides on a case-by-case basis whether, when and how to commit Defence Forces personnel to such operations, this is followed by Dail (parliament) approval and then UN authorisation. This mechanism provides a legal basis for deployment and actions. Military contingents of different nations are deployed to the host nation of the complex emergency under different apparatus. Humanitarian organisations attempt to provide assistance (e.g., humanitarian aid, protection of minorities, refugees and displaced persons, medical care and reconstruction) often parallel to the deployment of military forces, based on their own charter and mission. Having arrived in the host nation, all actors operate in the same operational environment.

To make the model operational, five main phases are identified; Planning, Formation, Assessment, Co-ordination and Evaluation & Feedback. Within the planning phase three steps are identified; the decision to cooperate or not is made by each of the actors (Yoshino and Rangan, 1995). If an actor concludes that cooperation is promising, the second step consists of the selection of an appropriate partner (Das and Teng, 1997) and the third step is to design the partnership (Hoffmann and Schlosser, 2001) which would include organisational structure, preparedness measures and training. A lack of co-ordination often leads to confusion at the last mile (Murray, 2005), collaborative agreements could be developed (Kaatrud *et al*, 2003) with the United Nations Joint Logistics Centre (UNJLC). Recently, many "traditional" transportation companies such as DHL or TNT logistics have entered the scene of disaster relief operations, establishing partnerships with the United Nations (Kovács and Spens, 2007). This should result in a detailed implementation plan describing the rights and duties of each partner.

The formation phase includes appeals management, pre-purchasing agreements which according to Murray (2005), many relief organizations have in situ with suppliers of drugs, tents, sheeting or blankets. Stock could be pre-positioned (Thomas, 2003). Bottlenecks are identified through the use of information technology, as argued by Long (1997), information systems are the single most important factor in determining the success or failure of a disaster relief operation. During the assessment phase needs assessment (including medical), environmental factors, infrastructure and requirements for secure, safe environment are considered. Because of geographical dispersion, insufficient or inaccurate communication between the field and the head offices of humanitarian organizations, and between different organizations co-ordination may be inadequate (Mileti, 1999, Oloruntoba and Gray, 2006). Assessing demand after a disaster includes a consideration of the cultural peculiarities of the disaster region (Beamon, 2004; Kovács and Spens, 2007).

Co-ordination is central to a successful humanitarian supply chain. Logistics co-ordination between NGOs has improved in recent humanitarian operations (Van Wassenhove and Samii, 2003) with shared equipment, assets or resources such as aircraft, trucks, food stores, forklifts etc., and with some agencies or even individuals designated as having the best local knowledge and contacts (Oloruntoba and Gray, 2006). Aid agencies receive many unsolicited and sometimes even unwanted donations (Kovács and Spens, 2007). Unsolicited supplies in fact clog airports and warehouses (Cassidy, 2003; Murray, 2005; Kovács and Spens, 2007) and create redundancies (Sowinski, 2003). Within the co-ordination phase there is a need to have open communications in coordinating with the actors and suppliers involved in the complex emergency. Since military forces should not be involved in a crisis for a long term (NATO, 2003), the partnership has to be terminated after completing the agreed plan. If both partners want to continue the relationship, a new plan must be developed. As Whitman (2000) poses the question, "What happens if the military leaves?" within the co-ordination phase of the model the transfer of tasks and responsibilities are considered. Whether planned or unplanned, to prevent the military from a long-term involvement in the crisis (e.g., long-term dependence on military resources by the local population, government, or humanitarian organisations), tasks and responsibilities have to be transferred (NATO, 2003). The final step of the model is to evaluate the partnership. This results in the final output of the model, the performance of the partnership for each of the participating actors. Having transferred tasks and responsibilities, it is very important to evaluate the partnership (Das and Teng, 1997). The main reasons are to determine the performance of the partnership and to facilitate the justification of finances to donor organisations, the communication between organisations, the process of lessons learned, and the accountability of the activities (Rubin, 1995). The evaluation of the partnership is the last step of the integrated model.