An initial investigation into the application of the military sea-basing concept to the provision of immediate relief in a rapid onset disaster

Peter Tatham[1]

Department of Defence Management and Security Analysis, Cranfield University, UK
Tel: +441793785734, Fax: +441793785029, p.h.tatham@cranfield.ac.uk

Gyöngyi Kovács

Department of Marketing, Supply Chain Management and Corporate Geography
HANKEN (Swedish School of Economics and Business Administration, Helsinki)
Tel.: +358943133241, Fax +358943133287, kovacs@hanken.fi

Abstract

Faced with a rapid onset natural disaster, much of the initial support provided by major UN Agencies and NGOs utilises expensive airfreight as the primary means of transporting relief aid to the effected country. Using the 2005 Pakistan earthquake as a case study, this paper reports initial research into an alternative approach called "sea-basing". This concept, which is already widely used by military forces, envisages a "floating warehouse" located close to a primary risk area. A suitably sized ship is held at very short notice to transit to the relevant country with a cargo containing sufficient food and non-food items (tents, tarpaulins, blankets etc) to meet the immediate needs of a significant number of beneficiaries. The paper will expose the relevant costs and benefits of the sea basing approach, and compare these with the costs of providing airfreight in support of the 2005 Pakistan earthquake.

Keywords: humanitarian logistics, sea-basing, disaster relief, inventory location, Pakistan Earthquake

An initial investigation into the application of the military sea-basing concept to the provision of immediate relief in a rapid onset disaster

1.   Introduction

Balancing the trade-off between efficiency and effectiveness is at the heart of the management of any supply chain or network.   Achieving cost reduction based on predictable demand without compromising the surge capacity that is needed to meet the unforeseen is one of the key routes to commercial success. But outside the world of business, logisticians in many other fields also face the challenge of successfully managing the transition between steady state and surge situations. 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. Thus, there is an increasing recognition that disaster response has much to gain from commercial supply chain management thinking (Thomas, 2005; Thomas & Kopczak, 2005; Trunick, 2005) and this, in turn, is leading to greater interest amongst academics (Kovács & Spens, 2006; Oloruntoba & Gray, 2006; van Wassenhove, 2006) as well as politicians and the general populace.

Different inventory management strategies have been proposed for use by the humanitarian logistician in preparation for immediate action during times of surge (i.e. in the immediate aftermath of a disaster). However, contrary to the prevailing trend in business logistics which generally promotes a reduction (if not an elimination) of inventory levels, humanitarian logisticians are urged to pre-position stock in disaster-prone areas (Beamon & Kotleba, 2006; Hale & Moberg, 2005) – albeit this is not a universally held view as others (e.g. Heigh, 2006) argue that stockpiling must be balanced with the benefit to be gained from local sourcing (with concomitant positive implications for the affected community). Nevertheless, if a pre-positioning approach

is adopted, it must take the potential effects of disasters themselves into account as these frequently result in the destruction or destabilisation of the physical infrastructure in the disaster region.

As a possible alternative strategy, this paper explores the concept of sea-basing as a means of pre-positioning resources in preparation for the relief of a rapid onset disaster. Sea-basing can best be described as the use of a floating warehouse that is located in the vicinity of a disaster-prone area, and which can move at relatively short notice to support the immediate response phase. In this paper, the concept of sea-basing is evaluated using data from the Pakistan earthquake (also known as Kashmir earthquake, or South Asia earthquake) of Oct 8, 2005.

The paper is structured as follows: in order to bound the scope of the work, disaster and disaster relief taxonomies are presented first, followed by a conceptualisation of sea-basing. The next section outlines the initial stages of the October 2005 Pakistan earthquake, before discussing the response of one particular humanitarian organisation, the International Federation of Red Cross and Red Crescent Societies (IFRC). This is followed by a comparison of the cost of providing initial relief aid using air freight with that of the sea-basing approach using a standard commercial container ship. The final section broadens the discussion to cover the potential additional benefits of using a bespoke vessel.

2.   *Disaster relief taxonomies*

Whilst the occurrence of "natural disasters" is not new *per se*, there is an increasing awareness of their consequences on individuals and populations, the physical infrastructure and the environment. This is due, not least of all, to the increasing and

timely availability of access to visual images presented through the medium of TV networks. For example, the International Business Leaders Forum argues that:

> "World attention to a disaster is shaped by the media and the tone and extent of [its] coverage." (IBLF, 2005)

Furthermore, it is argued that the number, nature and effect of such disasters is growing (Dilley *et al.,* 2005; Thomas & Kopczak, 2005; Wilton Park, 2005). Indeed, a recent assessment of the United Nations considers that:

> "[t]hough such figures tend to vary from year to year, overall trends suggest that disasters are becoming more frequent, severe and destructive."
>
> (UN, 2006, para 7).

But what constitutes a disaster? A disaster can broadly be defined as:

> "a disruption that physically affects a system as a whole and threatens its priorities and goals" (van Wassenhove, 2006, p.476).

That said, there is an ongoing debate in literature as to whether the term "disaster" should only be applied if the system in question needs assistance from outside its boundaries (as in Erdelen, 2005; Long & Wood, 1995), or whether calamities that are dealt with within the system (such as the US government's response to Hurricane Katrina, or the Indian government's decision not to accept foreign assistance after the 2004 Tsunami) should also be included in this definition. In any event, different types of disasters can be distinguished, and disaster taxonomies typically categorise disasters (and their responses) according to the warning time of a disaster (slow vs. rapid or sudden-onset disasters) and its causes (man-made vs. natural) (see Figure 1).

	Natural	Man-made
Sudden-onset	Earthquake Hurricane Tornadoes	Terrorist Attack Coup d'Etat Chemical Leak
Slow-onset	Famine Drought Poverty	Political Crisis Refugee Crisis

Figure 1: Categorising disasters (van Wassenhove, 2006, p.476)

The nature of the disaster relief activities differs not only across these different types of disasters, but also with respect to the duration of disaster relief programme. A generic differentiation can, therefore, be made between long-lasting events that are characterised by continuous aid work (e.g. famine relief), and disasters in which initial problems can be overcome in relatively short order (Kovács & Spens, 2006). Ludema & Roos (2000) further categorise disaster relief operations into emergency, elementary (or subsistence), rehabilitation and development relief (see Figure 2).

Emergency Relief	Elementary (Subsistence) Relief	Rehabilitation Relief	Development Relief
Immediate Disaster Relief	Supply of Basic Subsistence (food; Shelter etc)	Restoration of everyday life after a disaster	Aimed at improving the human systems (societies)

Figure 2: Typology of disaster relief operations (Ludema & Roos, 2000, p.144)

A similar phased approach to the management of such humanitarian disasters is offered by Long (1997), although he also suggests that in almost all cases there is a preparation phase a view that is supported by Kovács & Spens (2006) who use a three phase model: preparation, immediate response and reconstruction. A further insight is offered by Safran (2003) who (in a view that is shared by Houghton, 2006) usefully emphasises the cyclical nature of disaster relief (see Figure 3). Thus, the recovery phase of one

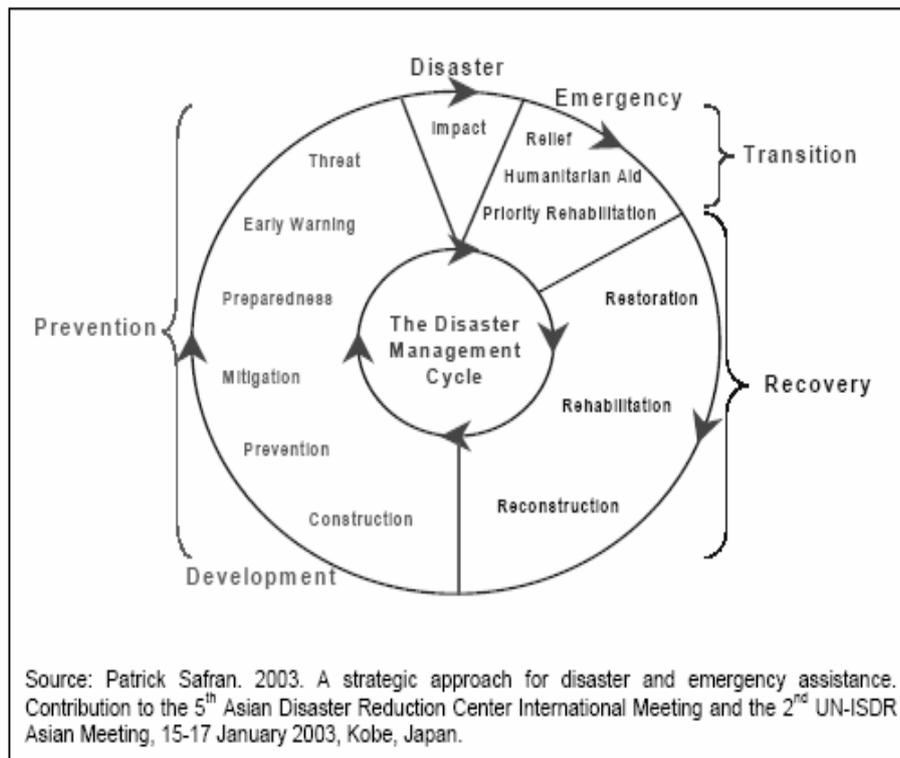disaster needs to link to a new prevention phase to mitigate the effects of future potential disasters.

Figure 3: Phases of disaster relief (Safran, P., 2003)

The focus of this paper is on rapid-onset natural disasters such as earthquakes, volcanoes, wildfires, hurricanes, tornadoes or floods. In particular, the paper focuses on the balance between the pre-positioning of stock (the preparation phase of a disaster) in order to ensure a rapid response when a disaster occurs, and the alternative strategy of quick response to satisfy a known requirement (ie flying supplies into an area to meet the needs of the beneficiaries). Thus, the effects of sea-basing are evaluated in the "immediate response" phase of Kovács & Spens (2006) and Long (1997); while they would fall into the category of "emergency relief" in Ludema & Roos' (2000) taxonomy, or be seen as part of the "transition" phase by Safran (2003) – which, for convenience, will be used within this paper.

3.   *The Pakistan earthquake*

An earthquake of magnitude 7.6 on the Richter scale occurred on 8th October 2005 at 0850 local time in an area centred 95km Northeast of Pakistan's capital (Islamabad). The quake caused damage over an area of some 30,000 sq km (ie approximately a circle with a radius of 100km from the epicentre), and the main event was followed by 978 aftershocks of magnitude 4.0 or above over the following three weeks. The Pakistan earthquake was one of the most serious of the world's recent natural disasters (for comparison, see Table I).

Table I: Comparative human impact of recent natural disasters

Event	Date	Human impact		
		Dead / missing	Injured	Displaced
Gujarat Earthquake (India)*	2001	20,805	116,836	600.000
Bam Earthquake (Iran)	2003	26,200	30,000	600,000
SE Asia Tsunami	2004	298,000	N/A	N/A
Hurricane Katrina (USA)**	2005	1,833	N/A	N/A
Hurricane Stan (Guatemala)	2005	2,000+	N/A	N/A
Pakistan Earthquake	*2005*	*80,361*	*79,000*	*3,300,000*
Yogyakarta Earthquake (Indonesia)	2006	5,749	35,568	600,000

Sources: *Earthquakes: United States Geological Survey (USGS), **Hurricanes: United States National Hurricane Center (USNHC)

The affected area of the Pakistan earthquake was similar in size to that of Belgium or the State of South Carolina, but is characterised by a harsh mountainous terrain with many villages located at considerable altitude. Some 40% of the affected population lives in such villages (Op Update 6, IFRC, 2005) which are supported by a network of tracks that are frequently only passable on foot or with pack animals, albeit there is a better road network in the base of the main valleys. The area is geologically extremely active being along the confluence of the Eurasian and Indian tectonic plates. However, the earthquake shock waves travelled along the steep sided valleys and this explains why the majority of the effects were felt in Pakistan and the Pakistan administered areas

of Kashmir; whilst India and Indian administered Kashmir (which are on the other side of the main mountain range) were relatively unscathed.

An indication of the severity of the earthquake can be gained from the following observations:

- Some 6,300 school buildings were damaged or destroyed in the earthquake and, as it struck on the morning of a normal school day, approximately 850 teachers and around 18,000 students were killed (IFRC, 2006).

- In addition to the destruction in the towns and cities (eg collapsed apartment blocks), over 400,000 rural homes were damaged or destroyed (IFRC, 2006). Moreover, because it was the month of Ramadan, many adults were taking a nap after their pre-dawn meal and, again, were caught in collapsing houses.

- Around 50% of the 800 health facilities in the area were destroyed or badly damaged (IFRC, 2006). This, together with the loss of life amongst medical and nursing personnel, limited the ability to treat those injured in the disaster.

The remoteness of the area, the destruction of such roads and bridges that existed, the difficulty of the terrain and the harsh winter conditions shortly after the earthquake all conspired to make the evaluation of the immediate needs of the population an extremely difficult undertaking. As a consequence, although some emergency goods arrived quite quickly from both within Pakistan and from other countries, significant volumes of international aid did not begin to reach Islamabad until some 6 days after the earthquake. Thereafter much of this international aid was delivered (at least for the first month) by air freight and, indeed, the use of air transport continued well into the new year (ie some 3 months after the earthquake).

Analysing the response timeline within this transition phase in more detail, it becomes evident that different stages can be distinguished. During an initial time period of 3-5 days after a disaster, a country must, in effect, use its indigenous resources to meet the challenge of providing emergency relief. The exact duration of this phase will, inevitably, reflect a wide number of variables, but the 3-5 day duration is also broadly in line with one of the IFRC logistics performance indicators, which is to deliver relief aid to 5,000 families (of an average of 5 persons) within 48 hours of the needs assessment reaching the IFRC HQ (Heigh, 2006). During this period indigenous NGOs (such as the Red Cross/Crescent National Societies) play a crucial role in helping to save and preserve life and in distributing aid to beneficiaries. However, given that the initial needs assessment can frequently take as much as 48 hours to complete, the total elapsed time before the first extra-regional Red Cross/Crescent aid reaches a disaster-stricken country is, typically, some 4 days after the onset of the disaster. At this point (which can be seen as the start of Safran's emergency phase, see Figure 3), the international community as a whole begins to make a significant contribution to the relief effort – usually in the form of personnel (medical, logistics, communication, cargo handling, etc), as well as through the air freight of relief supplies. In reality, developing an "established" supply chain takes a further period of time and, according to Heigh (2006), this was not achieved by the IFRC until ten days after the disaster (E+10). Such airborne relief may continue for a lengthy period but, not least given the cost of such flights, every effort is made to replace them with road or sea transport as soon as possible. For the purposes of this paper, therefore, the emergency phase is deemed to be complete once the relief pipeline has been established by sea or overland rather than by air. In the case of the Pakistan earthquake, this was assessed by the United Nations Joint Logistics Centre (UNJLC) to have taken place 37 days after the initial impact (Bulletin 16, UNJLC, 2005).

In terms of delivering the relief goods in support of the Pakistan earthquake, airfreight was the primary mode of transport into the country, with onward movement by truck, helicopter or donkey. Indeed, the response to this disaster exemplified international cooperation through the provision of a fleet of helicopters that, at its height, numbered just over 100 (Bulletin 16, UNJLC, 2005) – although, given than many of these helicopter assets were sourced from (and flown by) the military, not all NGOs were permitted by their charter to use these assets. Furthermore, whilst the figures are not entirely reliable (as there is potential for some double counting), an analysis of a variety of sources including data published by USAID, NATO, DFID, IFRC and UNJLC indicates that just under 200 cargo planes landed at Islamabad airport in the first thirty days after the earthquake (ie during the transition phase), carrying a total of around 3,900MT of supplies; a figure which increased to a total of around 10,000MT flown in by the end of the year.

4.   *Sea-basing in disaster relief*

Whilst there are obvious limitations to the involvement of (foreign) military actors in disaster relief (Ebersole, 2005; Kelly, 1996), military personnel are, nevertheless, often involved in disaster relief operations - for example as guards for relief organisations (Ebersole, 2005), in the prevention of (man-made) disasters (Alexander, 2002; O'Brien & Read, 2005; Trim, 2003), or actually taking part in the delivery of relief itself (Kelly, 1996). Furthermore, military logisticians share the same basic challenge as their humanitarian counterparts as both must have the plans, systems and materiel ready to transform their operations from a steady to a surge state in a very short timeframe. One way in which this can be accomplished in a military context is through the use of vessels as "floating warehouses", commonly termed "sea-basing". This sea-basing concept is widely in use within the Armed Forces of a number of countries to support

the initial insertion of soldiers into a potentially hostile environment. In this way, logistic support can be given to the deployed force until such time as a suitable base can be set up ashore.

This next section of the paper discusses the potential use of sea-basing for the purposes of disaster relief and evaluates its effectiveness with data from the Pakistan earthquake. In doing so, it has been assumed that the sea-based vessel will be located in Singapore in its dormant state. This country is at a strategic cross-road in South East Asia, with an anchorage that is relatively safe in terms of shelter and has a minimal piracy danger. Singapore is also very widely used to anchor numerous vessels for crew changes, repairs and whilst awaiting orders. Singapore has, therefore, a comprehensive set of support services for anchored vessels such as workboats to provide personnel, supplies, materials, bunkering services and repairs as necessary.

The vessel would be stocked with an appropriate selection of food and non-food items and, on the assumption that it is partially crewed with key personnel at all times, should be able to sail within 24 hours to a selected destination. Estimated transit times (at 14kt) to a number of potential ports in the area are shown in Figure 4. In the scenario of the Pakistan earthquake, a vessel could arrive in Karachi after 9 days after dispatch. To this must be added the unloading time (24-36 hours) and the in country transit time between Karachi and Islamabad (1585km) which would add some 2-3 days to the journey. Thus, in this scenario, the total elapsed time from the onset of the earthquake to the arrival of the goods from the sea-based vessel at Islamabad (i.e. the equivalent to the airhead) would have been some 15 days.
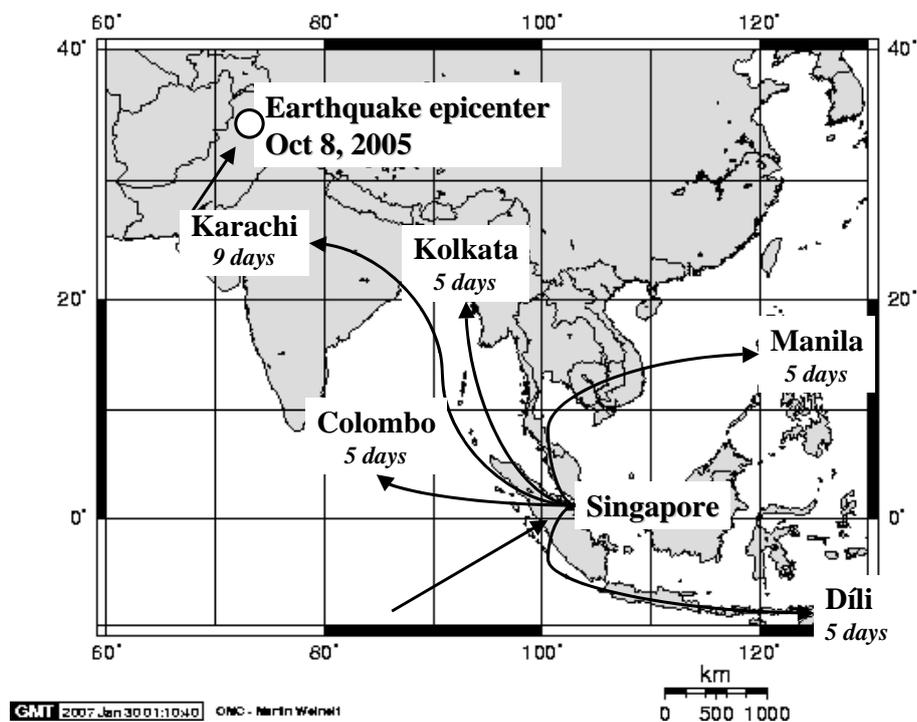
Figure 4: Transit times (at 14kt) from Singapore to selected destinations (drawn with OMC); calculations based on data from DDT (2007), times rounded up to the nearest whole day

A time comparison to the actual international relief per air freight shows that pre-positioned stock from a sea base could have arrived just 5 days later than the initial flow of aid provided by air freight, and furthermore the volume delivered by sea at E+15 was not matched until E+30 using air freight. The effect of sea basing is to reduce the time period in which the disaster is in the emergency phase by as much as 23 days. In the next section, further more detailed cost and volume comparisons between the use and air freight and the sea basing response to the Pakistan earthquake are presented. The broader feasibility of sea-basing in this region is then discussed in the sensitivity analysis section of the paper.

4.1 Comparing sea-basing to air freight

To evaluate the potential use of sea-basing in rapid onset disaster relief, data on volumes moved in the Pakistan earthquake was assembled from the operational reports of the IFRC (which are available from the IFRC website at www.ifrc.org. In addition,

the authors were granted access to IFRC databases that contain the detailed quantities, weights and volumes of relief aid that was transported to the area of the earthquake. This data shows that, during the first 30 days after the earthquake, the IFRC flew in some 70 flights containing around 1,750MT of equipment and stores. Using the mass and volume data for the relevant commodities drawn from the IFRC catalogue (IFRC, 2006a), it was possible to assess the number of 20ft ISO Containers (TEUs) that this would have required.

The resultant best estimate is that the total volume of IFRC airfreight moved during this period equates to 344 TEUs. Unfortunately, the data set did not contain all of the relevant weights and volumes – for example those of the Norwegian Field Hospital (that was moved to Pakistan in the first weeks of the relief operation) were not included. Furthermore, and almost inevitably given the degree of confusion that surrounds the initial stages of such a rapid onset disaster relief operation, there is potential for mis-recording of data. Therefore, in order to present a conservative estimate of the above metrics, they have been rounded up and the base case will assume that the total volume of airfreight transported by the IFRC in the first 30 days after the earthquake equate to 400 TEUs.

As a result, the cost data for sea-basing was related to a 500TEU (nominal) standard geared container vessel with a base in Singapore, and this was compared with data from the IFRC's response to the first 30 days of the Pakistan earthquake (ie, in effect, the transition phase in Figure 3). The reason for using a 500TEU (nominal) vessel reflects the limitations of useable vessel capacities in comparison to their nominal capacities – in practice, weight and stability restrictions mean that a 500TEU (nominal) vessel has a useable capacity of around 400 TEUs. The dimensions of such a vessel would be approximately:

- Length: 130m
- Breadth: 20m
- Draught: 7.5m (when fully laden)
- Displacement: 8,000 DWT
- Crew: 10-12
- Speed: 14kt

At the same time, limiting the vessel size in this way helps to ensure that most commercial ports would have the required materials handling capabilities to load/unload such a ship, as well sufficient water in their harbour to accommodate it.

The next stage of the analysis was to understand the transport cost for the airfreight used in support of the Pakistan earthquake. Whilst broadly similar, different sources offer different estimates for such costs:

- $100,000/flight (Heigh, 2006). On this basis, the cost to the IFRC for the air transport for the first 30 days = $7,000,000.

- $117,647/flight (NATO, 2005). On this basis, the cost to the IFRC for the air transport for the first 30 days = $8,235,000.

- $4/kg (Goodhand, 2006). On this basis, the cost to the IFRC for the air transport for the first 30 days = $8,640,000.

Again, in line with the adoption of conservative estimates in this analysis, the lowest of these estimates ($7M) will be used for comparison with sea-basing options. As an aside, whilst this figure alone may appear at first sight to be significant, it should be placed alongside the IFRC's total logistics costs (including stock procurement) for the

first 60 days of operations in Pakistan which are estimated to have exceeded $50M (Heigh, 2006).

As indicated earlier, the base case container ship to be used for comparison is a 500TEU (nominal) vessel. The movement of the required 400 TEUs can be achieved by: (A) purchase of a suitable vessel (new or second hand), (B) hire of capacity on an existing vessel, or (C) chartered on a long-term basis. The actual charges incurred by the owner/charter differ across the three options as shown in Table II.

Table II: Comparative charges for sea-basing options

	Purchase (Option A)	Hire of Capacity (Option B)	Long Term Charter (Option C)
Vessel Purchase	√		
Capacity Hire		√	
Vessel Charter			√
Crew	√		
Vessel Maintenance	√		
Vessel Insurance	√		
Fuel	√		√
Port Charges	√		√
Container On/Off Load	√		√
Container Purchase/Hire	√	√	√
Container Repatriation	√		√
Container Repairs	√	√	√

Option A envisages the purchase of a 500 TEU vessel. Such a ship would cost in the order of $15.5M (new) to $9M (10 years old) (DSCL, 2006). However, as indicated in Table II, purchasing a vessel would result in additional costs (such as crewing, maintenance and ship insurance). Therefore, whilst this option might prove feasible once the sea-basing concept has been proven, it is a very risky approach at this stage of the maturity of the research.

In Option B, the 400 TEU worth of equipment is kept ashore, and a vessel is chartered only on the basis of actual needs. Standing arrangements could be set up with an appropriate shipping company (it is estimated that there are 14 services/week operating out of Singapore to various ports in the SE Asia area (DSCL, 2006)) that would aim to guarantee a response time – i.e. a suitable ship to be available and ready to load in Singapore within, say, 24-48 hours. Although this option would be relatively cheap (even with a guaranteed response time), it would increase the lead time between the disaster and the arrival of the relief stores by 3-5 days (vessel arrival in port + loading time), thereby compromising the flexibility of sea-basing. Given the conservative approach to the analysis within this paper, this option has been rejected for primary analysis in the light of the additional delay that would be incurred. However, it will be considered further in Section 5 where alternatives to the base case are discussed. Meanwhile, for the base case purposes, Option C is seen as the preferred alternative, and the estimated annual costs of this approach are summarised in **Table III**.

Table III: Annual costs for Option C

Item	Base of calculation	Source of cost estimate	Annual Cost ($M)
Charter of 500TEU geared vessel	Daily rate of $7,500	DSCL	2.738
Fuel/Oil etc	20 Days/Year at sea @ 20MT/Day (IFO380 = $275/MT) + 345 Days/Year at anchor @ 2 MT/Day. (MDO = $520/MT)	DSCL and www.bunkerworld.com	0.469
Port Charges	Based on "layup" rate of $1/NRT/Week	DSCL	0.230
Container Hire	$1.10/Container/Day	DSCL	0.161
Container On and Off Load	$100/Container On + $100/Container Off	DSCL	0.080
Container Back Load On and Off	$100/Container On + $100/Container Off	DSCL	0.080
Container Back Shipping	$250/Container	DSCL	0.100
TOTAL			**3.857**

It should be noted that the above table does not include the in-country transit costs. These are difficult to forecast as they will reflect both the distance between the port and the disaster area, and the country specific trucking rates. Furthermore, depending on the relative location of the airhead, the container port and the disaster location, the differential between the air and sea freight options may be positive of negative. A final point is that, as was the case for the Pakistan earthquake, trucking may be provided at reduce rates or even free of charge (as was the case for Atlas Logistique – a French NGO operating in Pakistan) (UNJLC, 2005, Bulletin No 4).

4.2   Summarising the discussion of the Base Case

In summary, the annual cost of a long term charter for a 500TEU geared container ship, with 20 days at sea in any given year is estimated at around $3.9M. Therefore, using the Pakistan earthquake as a case study, this would deliver 400 TEUs from Singapore to Islamabad no later than **E+15** at a cost of just under **$4M**. This should be compared with the equivalent using airfreight in which the 400 TEUs were delivered at **E+30** at a cost of around **$7M,** ie nearly double the cost in a twice as long time period.

Apart from cost considerations, the broader positive and negative aspects of sea-basing need to be discussed and, in the humanitarian context, the advantages of sea-basing are perceived to be:

- Its inherent flexibility. The choice of disembarkation location can be selected as the anatomy of the disaster unfolds, and in some cases (eg cyclones) the vessel could be pre-deployed towards the danger area as soon as an early warning is published, thereby reducing the elapsed time between the disaster occurring and the arrival of the relief goods.

17

- Avoidance of single point of failure in the supply network. Reliance on a single airport (eg Banda Aceh in the 2004 Asian tsunami) created major difficulties for the supply network when this airport became overwhelmed by the volume of aircraft (and supplies) using it. On the other hand, a "geared" container vessel can use its own derricks to offload the cargo in cases where the harbour facilities have been substantially reduced (as occurred in many countries affected by the 2004 tsunami (IFRC, 2004)) as well as, potentially, having a number of port options that it can use.

- More broadly, the environmental impact of using one vessel is several orders of magnitude less that the equivalent resulting from the use air cargo planes.

Clearly the concept has a number of disadvantages which include:

- The large unit load that must be deployed. As will discussed above, the vessel is likely to be of significant size and, hence, with a large capacity. This is ideal for responding to major disasters; less so for ones that require only limited assistance.

- A large volume of stock is tied up in the vessel which, apart from capital cost considerations, may create stock turnover issues.

- Whilst, at a governmental level, there is general acceptance of the use of air freight in response to a humanitarian disaster, the novel nature of the sea

basing concept may result in some unforeseen bureaucratic delay to the smooth disembarkation and customs clearance of the relief goods.

5.   *Feasibility and sensitivity analyses*

Whilst at first pass, a financial comparison between the provision of emergency relief through sea-basing and air freight in support of the Pakistan earthquake would appear to be overwhelmingly favour the sea-based option, it is important to evaluate the feasibility of this solution. Three analyses have been carried out for this purpose, (1) a feasibility analysis looking at the probability of disasters in the South East Asia region, (2) sensitivity analyses related to key cost drivers, and (3) a further consideration of the potential for using existing commercial cargo capacity (ie revisiting option B).

5.1   *Assessing the probability of disasters in South East Asia*

Given that inventory turnover is a major facilitator or inhibitor of the very idea of pre-positioning stock in a disaster region, it is important to assess the probability of a significant disaster occurring in the South East Asia region.

Fortuitously, there is no "guarantee" that a natural disaster will take place in any particular geographic location in any given year. For example, even the occurrence of hurricanes in the Gulf of Mexico/Southern United States region shows a very irregular pattern:

Table IV: Hurricanes in 2005 and 2006 in the Gulf of Mexico

	Tropical Storms	Hurricanes	Major Hurricanes
40 Year Average	11	6	2
2005 Season	11	8	7
2006 Season	9	5	2

Source: United States National Hurricane Center (US NHC)

Furthermore, whilst 2005 saw the highest total number of hurricanes and tropical storms on record (15) (Lea & Saunders, 2006), in 2006, although 3 systems made landfall on the US mainland, none was classified as a hurricane by the time it reached the coast.

Nevertheless, it is recognised that from a purely financial perspective, for the sea-basing concept to be viable it requires a major natural disaster to occur at least once every two years within its potential area of operation (ie Figure 4). How realistic is this? Some of the most respected data in this area has been produced by the Center for Hazards and Risk Research at Columbia University and in a recent global risk analysis, Dilley *et al* (2005, p3) note that although their work is unable to offer a view on the:

> "*absolute* level of risk posed by any specific hazard of combination of hazards, [the data is] adequate for identifying areas that are at relatively higher single or multiple hazard risk." (emphasis in original)

The work of these authors uses sophisticated modelling to understand the risks of mortality, total economic loss and economic loss as a proportion of GDP density. From the humanitarian perspective, the first of these three metrics is the most important and from Dilley and his colleagues' work it can be seen that, in relation to the hazards of cyclone, flood, earthquake and landslide, the area of Southern Asia falls into the "relatively high risk" category. This is reinforced by Dilley (2005) who states that:

> "[d]isaster-related mortality risks associated with hydro-meteorological hazards are highest across the sub-tropical zones, with drought related mortality risks being highest in semi-arid regions of Africa. *Mortality risks associated with geo-physical hazards are highest along plate boundaries, around the Pacific rim and across southern Asia. Some countries such as the Philippines and Indonesia are at a high risk from all three types of hazards.*" (Emphasis added)

Thus, the evidence would suggest that the likelihood of a natural disaster occurring in the area under consideration is considerable – however, it is recognised that it is not possible to indicate a frequency. That said, four significant disasters have taken place

within the region of interest since 2001 (see Table I), ie an average of more than one every 24 months. Therefore it is concluded that, if the sea-basing concept is indeed to be operationalised, then the geographic area described in this paper presents a highly credible basis for continued research effort.

5.2   *Cost drivers of sea-basing*

Another issue to consider in a sensitivity analysis is to review the key cost drivers of sea-basing. Two major cost drivers have been identified, the charter hire itself and the cost of fuel. Long-term charter costs for a 500TEU geared container ship have fluctuated between $4-5,000/day (in 2000) to $9,175/day (in 2005) (DSCL, 2006). While this latter figure has declined to $7,500/day by the end of 2006 (with a further downward trend forecast), for the purposes of a sensitivity analysis, the high-end of $9,175/day (rounded up to $10,000/day) will be used. The cost of the necessary fuel (380 Centistoke – IFO 380) has varied between $270/MT and $340/MT during 2006, so once again, the higher figure has been used in the analysis. Finally, as acknowledged earlier in the case study, due to the paucity of robust data, the transposition from the estimated weight of airfreight to a number of TEUs (driven by volume) may be inaccurate. To overcome this, the costs of a larger (750TEU (nominal); 650 TEUs actual) and smaller (250TEU (nominal); 200 TEUs (actual) vessel are also compared.

Table V: Cost sensitivity of sea-basing

Cost item	Annual costs ($M)			
	250 TEU (Nominal) / 200 TEU (Actual) / Average Estimate	Base Case / 500 TEU (Nominal) / 400 TEU (Actual) / Average Estimate	500 TEU (Nominal) / 400 TEU (Actual) / High End Estimate	750 TEU (Nominal) / 650 TEU (Actual) / Average Estimate
Ship Charter	2.010	2.738	3.650*	3.140
Fuel/Oil etc	0.567**	0.469	0.469	0.496
Port Charges	0.143	0.230	0.230	0.286
Container Hire	0.080	0.161	0.161	0.261
Container On and Off Load	0.040	0.080	0.080	0.130
Container Backload On & Offload	0.040	0.080	0.080	0.130
Container Backload	0.050	0.100	0.100	0.162
TOTAL	**2.930**	**3.857**	**4.770**	**4.605**

* based on 10,000$ daily   ** based on MDO @ $520/MT at sea and anchor

Based on this sensitivity analysis, it can be noted that even a high-end cost estimate for a 500TEU vessel (just over $4.75M) continues to incur significantly less costs than the equivalent airfreight ($7M). Furthermore, sea-basing also proves to be a cheaper option if using a 750TEU and, given that such vessels have a higher passage speed (15-16kt), this would reduce the lead time for responding to a disaster by 12-24 hours depending on destination. Such a vessel would almost certainly exceed the carrying capacity needed by the IFRC during the transition phase, but were the IFRC to coordinate its requirements with another of the major NGOs, then clearly there could be mutual benefit. Conversely, although cheaper to charter, a 250TEU vessel will lead to an increased transit time of 12-24 hours.

5.3   Hiring capacity for sea-basing

As discussed in section 4.1, the base case – whilst clearly of significant benefit in the major emergency scenario (e.g. a repeat of the Pakistan earthquake), does not offer the

flexibility to allow support for lesser scale emergencies. The aim of this section is, therefore, to explore (briefly) the use of Option B which (to recap) would require:

- The logistic organisation to load the required number of containers with the desired mix of food and non-food items (estimate 24-48 hours). This, in turn, implies the existence of a local warehouse (such as those of the IFRC and/or World Food Programme (WFP)) and/or a surge capacity from the local economy.

- A vessel of the appropriate size to be available in the port of embarkation. This element of the process could be de-risked through some form of standing arrangement with a shipping company and/or the use of premium payments to secure the required cargo capacity. This activity may involve unloading some containers from a vessel and replacing them with the relief goods. In any event, this would (ideally) take place as a parallel activity to the preparation of the containers, but on a conservative basis an additional 24 hours will be assumed.

- The vessel will then make its transit to the port of disembarkation. Whilst many shipping companies serve the geographic area under consideration, there is no guarantee that the individual vessel's planned route will take it directly to the desired destination. It may, therefore, be necessary to pay a premium to achieve this.

The comparable cost for this option is as follows:

Table VII: Estimate of the Cost of Option B (Hire of Capacity) based on Singapore to Karachi (and return)

Cost item	250 TEU (Nominal) 200 TEU (Actual) Average Estimate	500 TEU (Nominal) 400 TEU (Actual) Average Estimate	750 TEU (Nominal) 650 TEU (Actual) Average Estimate
Hire of Capacity (Outward Leg)*	0.170	0.340	0.552
Hire of Capacity (Return Leg)	0.070	0.140	0.228
Container Hire	0.080	0.161	0.261
TOTAL	**0.320**	**0.641**	**1.041**

* Because of the patterns of trade in the Asian area, the transport cost for Singapore to Karachi at $850/TEU (estimated) is over double the return leg at $350/TEU. (Source: DSCL, 2006)

In summary, this option is dramatically cheaper than the base case of moving 400 TEUs ($0.641M v $3.890M), but suffers from two disadvantages.

- Firstly, the initial load time is increased by 24-48 hours (reflecting the time needed to pack the ISO containers with the specific stock needed for the particular emergency). In the case of the Pakistan earthquake, this would have seen the arrival of the emergency goods at E+16 or E+17 (compared with E+15) in the base case. Nevertheless, this is delivers 400TEUs significantly faster than the air freight equivalent (E+30)

- Secondly, it relies on the availability of the necessary cargo capacity at the point of embarkation within the prescribed timescale (approx 48 hours). Whilst, theoretically, this should not present a significant risk, clearly it is a fundamental element of the whole sea-basing concept.

Nevertheless, the differential in cost is best demonstrated by the following table:

Table VIIII: Estimate of the Break Even Point for Options B and C

	250 TEU (Nominal) 200 TEU (Actual) Average Estimate	500 TEU (Nominal) 400 TEU (Actual) Average Estimate	750 TEU (Nominal) 650 TEU (Actual) Average Estimate
Cost of Option B	0.320	0.641	1.041
Cost of Option C	2.943	3.890	4.599
Break Even Point (Trips/Year)	9.2	6.1	4.4

In other words, for the annual cost of a long term charter to carry 200 TEUs (actual), it would be possible to take the same 200 TEUs on 9 round trips within the area of interest in a given year using existing commercial carrier capacity..

5.4   *Extending the capabilities of sea-basing*

Whilst this paper has evaluated only the simplest form of sea-basing for the purposes of disaster relief, i.e. the use of a floating warehouse, the original concept of sea-basing has been used with a variety of extensions in the military context. To mimic the broad range of capabilities that are available in such a purpose built military vessel would require not only the ship itself (which almost certainly could not be chartered and would, therefore, incur a considerable capital outlay), but also a larger (and more expensive) crew skilled in the operation of relevant equipment. That said, purpose-built vessels could include enhanced capabilities and, although further research would be needed to understand how such facilities might be employed in practice, some possibilities might include:

:

- Provision of an "operations room" with associated communications equipment for the local command and control of the relief effort.

- Medical facilities. These could be relatively limited or, through the sacrificing of some of the cargo space, could allow the installation of a field hospital. (As an example, such a hospital was carried in the Royal Fleet Auxiliary ARGUS, for many years).

- Secure accommodation (and associated rest and relaxation facilities) for humanitarian teams.

- A flight deck (with or without hangar facilities) that allows for the transfer of personnel and/or equipment. The effectiveness of helicopter operations is, however, limited by the prevailing sea and wind conditions and is, therefore, not necessarily a reliable transport means. Furthermore, it cannot be assumed that the contents of the containers can be unloaded at sea (and, thereby, made available for on move by helicopter) as the stacking of the containers is likely to preclude this.

- Landing craft could also, theoretically, be carried. However, once again, the operation of these is limited by sea and states and, in addition, the above restriction on the transfer of cargo from containers applies.

- In addition to its own fuel requirement, the vessel could provide a bulk storage capability for fuel that can be used in support of the disaster (e.g. diesel for vehicles, generators etc). Similarly, it could carry the facilities for bulk water purification and subsequent transport in country.

- The basic container vessel could also carry vehicles (e.g. 4*4s as well as larger equipment such as diggers and/or bulldozers) and heavy plant such as cement mixers and (small) rock crushers etc.

6. *Concluding discussion*

The aim of this paper was to carry out an initial evaluation of the potential for the use of sea-basing in the transition phases of a rapid onset disaster. The cost and practicality of the use of a standard 500TEU (nominal) commercial container ship were compared with similar data from the IFRC's support to the 2005 Pakistan earthquake. This analysis showed that, had it been operational at the time of the earthquake, then a sea-based response could have delivered 400 TEUs of relief goods within 15 days of the disaster at a cost of some $4M. This should be compared with the 30 days that it actually took the IFRC to fly in a similar volume of supplies at a cost of some $7M.

The sensitivity of the sea-based cost assumptions was tested and, in the worst case, the cost of this option rose to $4.87M – a figure that remains highly advantageous compared with airfreight.

To be cost–effective, it is however recognised that a major disaster must take place within the operational area approximately once every two years. Whilst in recent history this requirement has, unfortunately, been all too well fulfilled, there is no guarantee that a similar frequency of such disasters will pertain in the future – albeit, as noted in the introduction to the paper, the trend is towards a greater frequency and severity of natural disasters. Nevertheless, the proposed operational area is highly geologically active leading to volcanoes, earthquakes and tsunamis; it is also subject to other natural disasters such as fires, floods and famine. Thus an assumption that a

major disaster will continue to occur at least once every two years does not seem unreasonable.

It is also recognised that the geographical closeness of the actual disaster site to the sea is another limiting factor, but this can be offset by the potential availability of a number of disembarkation locations and avoidance of the "single point of failure" (eg the difficulties of supporting a relief operation from a single airport such as Banda Aceh in the 2004 Asia tsunami).

Finally, and perhaps most critically of all, the sea-basing concept invites the donor community to finance a capability which, like an insurance policy, may never be used. This challenges the historic behaviour of donors who have shown a marked reluctance to fund such preparation phase activities in humanitarian logistics. It would be possible to mitigate the high cost of the base case by use of capacity taken up from the commercial container transport market, and this has the potential to reduce the cost of transporting the 400 TEUs by $3.25M. However such an approach introduces a major element of risk in that it removes the guaranteed availability inherent in the base case under which the vessel is held on a long term charter.

Thus, whilst this initial study has clearly demonstrated a *prima facie* case for the use of the sea-basing concept, further research is needed to investigate each of the constraints and limitations described above and to evaluate the efficacy of the model in a broader number of scenarios and geographic locations in order to provide comparative data.

References

Alexander, D., 2002. From civil protection to civil defence – and back again. *Disaster Prevention and Management,* 11 (3), 209-213.

Beamon, B.M. & Kotleba, S.A., 2006. Inventory management support systems for emergency humanitarian relief operations in South Sudan. *International Journal of Logistics Management,* 17 (2), 187-212.

Dilley, M., Chen, R. S., Deichmann, U., Lerner-Lam, A. L., & Arnold, M., 2005. *Natural Disaster Hotspots: A Global Risk Analysis.* At: www.proventionconsortium.org accessed 2 Feb 2007.

Dilley, M., 2005. Setting Priorities: Global Patterns of Disaster Risk. *Proceedings of a Scientific Discussion on Extreme Natural Hazards*. Royal Society, London, 26-27 Oct, 2005.

DDT (2007): Dataloy Distance Table, at www.dataloy.com, accessed 23 Feb 2007.

DSCL (Drewry Shipping Consutants Ltd), 2006. *Estimated development of new build shipping prices*. At: www.drewry.co.uk accessed 2 Feb 2007.

Ebersole, J.M., 1995. Mohonk criteria for humanitarian assistance in complex emergencies. *Disaster Prevention and Management,* 4 (3), 14-24.

Erdelen, W., 2005. Presentation by the Assistant Director General for Natural Sciences, UNESCO at UK Natural Hazard Working Group Meeting 24 Feb 2005. As quoted in Milner, H. C. (2005) Can Humanitarian Aid. Disaster Relief Operations be more effective? *Cranfield University Unpublished MSc Dissertation*, Aug 05.

Hale, T. & Moberg, C.R., 2005. Improving supply chain disaster preparedness. A decision process for secure site location. *International Journal of Physical Distribution and Logistics Management,* 35 (3), 195-207.

Houghton, R., 2005. Tsunami Emergency: Lessons from Previous Natural Disasters. Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP). At www.odi.org.uk/ALNAP/publications/lessons_learned.htm accessed 5 Feb 2007.

IBLF (International Business Leaders Forum), 2005. Best Intentions, Complex Realities. *Report of the IBLF Tsunami Recovery Partnership*. At: www.dec.org.uk, accessed 3 Jul 2006.

IFRC, 2004. *Asia Earthquake and Tsunamis – Operations Update.* At: www.ifrc.org accessed 2 Feb 2007.

IFRC, 2005. *Operational Updates for Pakistan Earthquake.* At: www.ifrc.org accessed 10 Feb 2007.

IFRC, 2006. Pakistan Earthquake FACTS AND FIGURES SHEET – 13 September 2006. At www.ifrc.org accessed 10 Feb 2007.

IFRC, 2006a. Emergency relief items catalogue. At: www.icrc.org/emergency-items/, accessed 29 Jan 2007.

Kelly, C., 1996. Limitations to the use of military resources for foreign disaster assistance. *Disaster Prevention and Management,* 5 (1), 22-29.

Kovács, G., & Spens, K. M., 2006. Humanitarian Logistics in Disaster Relief Operations. *Proceedings of 18th Annual NOFOMA Conference,* Oslo, 8-9 Jun 2006.

Lea, A. S., & Saunders, M. A., 2006. How well forecast were the 2004 and 2005 Atlantic and US hurricane seasons? *Weather*, Vol 61,No 9, p245-249.

Long, D. C. & Wood, D.F., 1995. The logistics of famine relief. *Journal of Business Logistics,* 16 (1), 213-229.

Long, D. C., 1997. Logistics for disaster relief: Engineering on the run. *IIE Solutions*. 29 (6), 26-29.

Ludema, M. W., & Roos, H. B., 2000. Military and civil logistic support of humanitarian relief operations. *Proceedings of the 10th INCOSE Annual International Symposium*, Minneapolis, 16-20 Jul.

NATO (North Atlantic Treaty Organisation), 2005. *All NATO countries contribute to Pakistan Relief*. At: www.nato.int/shape/news/2005/pakistan_contributions.htm, accessed 29 Jan 2007.

O'Brien, G. & Read, P., 2005. Future UK emergency management: new wine, old skin? *Disaster Prevention and Management,* 14 (3), 353-361.

Oloruntoba, R. & Gray, R., 2006. Humanitarian aid: an agile supply chain? *Supply Chain Management – An International Journal,* 11 (2), 115-120.

Safran, P., 2003. A strategic approach for disaster and emergency assistance. *Contribution to the 5th Asian Disaster Reduction Center International Meeting and the 2nd UN-ISDR Asian Meeting*, 15-17 Jan 2003, Kobe, Japan. At: http://www.adb.org/Documents/Policies/Disaster_Emergency/disaster_emergency.pdf, accessed 29 Jan 2007

Thomas, A. S., 2005. Humanitarian Logistics: Matching Recognition with Responsibility. *Asia-Pacific Development Review,* 21 Jun 05.

Thomas, A. S. & Kopczak, L., 2005. *From logistics to supply chain management.* At: http://www.fritzinstitute.org/PDFs/WhitePaper/FromLogisticsto.pdf accessed 27 Jun 06, accessed 29 Jan 2007.

Trim, P.R.J., 2003. Disaster management and the role of the intelligence and security services. *Disaster Prevention and Management,* 12 (1), 6-15.

Trunick, P. A., 2005. Special report: Delivering relief to tsunami victims. *Logistics Today*, 46 (2), 1-3.

UN (United Nations), 2006. Strengthening of the coordination of emergency humanitarian assistance of the United Nations. *Report of the Secretary-General to the General Assembly Economic and Social Council.* Report No A/61/85 –E/2006/81 dated 2 June 2006. At: www.un.org accessed 2 Sep 2006.

UNJLC, 2005. *UNJLC Pakistan Earthquake Bulletins.* At: www.unjlc.org/23003/pakistan/bulletins accessed 2 Feb 2007.

Van Wassenhove, L. N., 2006. Humanitarian Aid Logistics: supply chain management in high gear. *Journal of the Operational Research Society.* 57 (5), 475-589.

Wilton Park, 2005. Improving National and Regional Disaster Response Capacity. *Report of Wilton Park Conference WPS05/29.* At: www.wiltonpark.org.uk, accessed 4 Jul 2006.

Oral sources:

Goodhand, M., 2006. Personal communication to the authors from the head of logistics, UK Red Cross.

Heigh, I., 2006. Personal communication to the authors from the deputy head of logistics, IFRC.