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Last Mile Logistics for Disaster Relief Supply Chain Management

Challenges and Opportunities for Humanitarian Aid and Emergency Relief

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Table of Contents

Table of Figures

List of Abbreviations

3PL	Third Party Logistics
FUNDESUMA	A non-profit, non-governmental organization
ITS	Intelligent Transportation Systems
NGO	Non-Governmental Organization
SUMA	The Humanitarian Supply Management System
UN	United Nations
UNHRD	United Nations Humanitarian Response Depot

1 Introduction

Due to the latest catastrophes caused by both man and nature, humanitarian logistics has received increasing interest from academics, practitioners and specialists. These interests are increased as well by an expanding market of disaster relief and by the fact that disaster relief supply chains are complex and dynamic, not to mention that they have a lot of uncertainties that make operations very complicated.[1] Especially in disaster relief, the supply chains have to be fast, agile and flexible in order to rapidly provide the appropriate amount, and type of emergency supplies, to minimize human suffering or death.

The last mile distribution is the final stage of the disaster relief supply chain, i.e. the delivery of relief supplies from local distribution centres to beneficiaries affected by disasters. The main problems for the last mile are:[2]

- Supplies have to be carried out rapidly in an environment with destabilized infrastructures
- Limitations related to transportation resources and emergency supplies
- Lack of coordination among relief actors
- Insufficient information about demand and need for help

To solve these problems, the private sector approaches of the last mile can be conducted and innovative technologies can be implemented.

The aim of this paper is to give an overview of supply chains in disaster relief, identify the main problems of the last mile distribution in disaster relief operations, describe optimization possibilities of the private sector, and examine the applicability for disaster situations.

In the second chapter we will give an overview of the entire disaster relief supply chain and point out the problems and challenges that are faced. In chapter three we will define the last mile model as a part of the disaster relief

[1] Thomas and Rock Kopczak (2005)
[2] Balcik et. al (2008)

supply chain and explain the unique characteristics of this special type of last mile distribution. In the last part of the chapter, the problems and challenges of the last mile approach in disaster relief will be discussed. Therefore, we will point out the four main problems in the fields of the infrastructure, transportation, coordination and information.

In chapter four we will then present optimization opportunities for these problems. We will introduce optimization approaches of the private sector from the last few years and innovative technologies for future optimization. To conclude we will discuss how, and if, these approaches can be implemented to the last mile distribution in disaster relief and under which circumstances they can be.

In the last chapter we will conclude the paper and give a short outlook on further improvements as well as future research possibilities.

2 Disaster Relief Supply Chains

Humanitarian logistics occur in different phases and time periods to help an affected region or affected people after a catastrophe. Even if there are a lot of different stages for a disaster response there are two main streams of humanitarian logistics. The first one has impact on the immediate response after a disaster, the actual disaster relief. This period includes the preparation for disasters to respond and react as quickly as possible and the first days or weeks after the disaster occurred. Secondly there is the continuous aid work, like the reconstruction and development of a region or management of refugee camps.[3] This paper will focus on the preparation phase and the immediate response after a catastrophe occurred, the disaster relief. Figure 6 in the appendix gives a better demonstration of the relief life cycle.

In the last years the humanitarian aid and therefore the disaster relief has expanded a lot. This is mainly caused by the increasing number of disasters and the increasing population on earth. The average number of disasters from 2000-2004 was 55% higher compared to 1995-1999 and 33% more people were affected by these disasters in the same time span.[4] This trend is not supposed to stop. Over the next 50 years disasters both natural and man-made, are supposed to increase five fold.[5] To meet the increasing needs of a working disaster response, a good supply chain setup must exist.

One reason why supply chain management and logistics are getting more attention in the humanitarian sector is because benefits from it were recognised and some best practices have shown the advantages. As one part of the supply chain setup, logistics have always been an important factor in disaster relief: logistics efforts can account for up to 80% of disaster relief.[6]

But a disaster relief supply chain has some very specific characteristics and confronts a lot of special challenges and problems. In the following we will describe the uniqueness's of a disaster relief supply chain.

[3] Kovacs and Spens (2007)
[4] IFRC (2005)
[5] Thomas and Rock Kopczak (2005)

[6] Trunick (2005b)

2.1 Characteristics

Before looking at the characteristics of a disaster relief supply chain we will introduce the definition of the term supply chain. *"A supply chain is essentially a network consisting of suppliers, manufacturers, distributors, retailers and customers. The network supports three types of 'flows' that require careful design and close coordination: material flows, information flows and financial flows".*[7]

Effective supply chains in the humanitarian as well as nowadays private sector have to *"be able to respond to multiple interventions, often on a global scale, as quickly as possible and within a short time frame".*[8] These general requirements are facing complex problems of the unknown and unpredictability in the humanitarian sector. Logisticians in disaster relief operations don't know when, where, what, how much, where from and how many times demand is required in the early days of the post disaster response.

These information depend on the type of the disaster, which can come up in very different ways. But disasters can be characterized with the following approach. On the one side one can differentiate between natural and man-made disasters and on the other side there are sudden-onset and slow-onset disasters. Figure 1 explains this segmentation of disasters and gives examples for each case. As one can see, wars are not an example of man-made disasters, since they are a category on their own and most organizations do not get included until the fighting didn't stop.[9]

As there are many different types of disasters there is not just one single supply chain setup, but many different and unique setups. Figure 2 shows an approach of a sequence for a typical supply chain.[10] As one can see, private donations are not included in this approach. Mostly these types of donations go directly to the international or local organizations. But as private donations are often just disaster and operation related, for example after the Tsunami

[7] Van Wassenhove (2006)
[8] ibid
[9] Van Wassehove (2006)
[10] Oloruntoba and Gray (2006)

2004 in the Indian ocean, they are really irregular and don't finance most long-term, administrative disaster relief systems.

	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 Explaning disasters *(Source: Van Wassenhove, 2006)*

Figure 2 A typical humanitarian supply chain *(Source: Oloruntoba and Gray, 2006)*

Even if there are many different types of humanitarian supply chains, all humanitarian organizations work for the same principles of humanity, neutrality and impartiality.[11] These three principles define the 'humanitarian space'. (Figure 3) This space occurs virtually and physically. Virtually the space gives humanitarians a framework for their decisions to make sure they remain within an ethical context. Physically the space provides a "zone of tranquillity" where civilians, non-combatants and aid workers are protected from battles and fulfil their operations. But as seen in media this protection does not always exist due to misunderstandings and confusion. An example

[11] Van Wassenhove (2006)

would be a UN vehicle that got shot at a petrol station in the Iraq conflict presumably by an angry civilian who thought the vehicle was queue jumping.[12]

One of the key characteristics for the complexity of a disaster relief supply chain is the number and diversity of stakeholders. First there is the public sector with governmental agencies, emergency relief mechanism and local authorities like the military. On the other hand there is the private sector with corporations, service providers, good suppliers and individuals. In between there is the international community and the large and small aid agencies. And finally there is the society at large, which is exposed to unexpected changes with the media as a special part, because it has an important impact on the private donations and the way organizations work during their operations, as they want to be seen in the media.[13] All these stakeholders have to be coordinated and they often don't work in a cooperative, but a competitive way. E.g., there is a big competition between the organizations for donations or supplies, which can have a negative impact on the operations or the way donations are spend. This competition can lead to increased prices of emergency supplies, due to increasing demand of organizations at the same time and limited available amount. As a result prices of supplies will be raised and donations will not optimally be used.

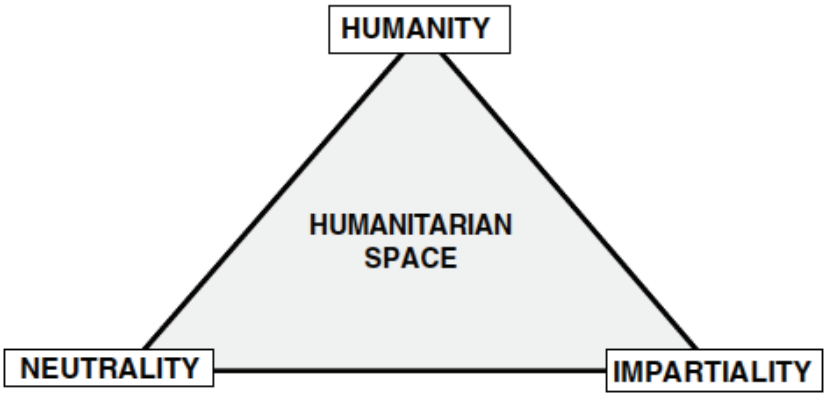

Figure 3 Humanitarian Space *(Source: Tomasini and Van Wassenhove, 2004)*

[12] ibid
[13] Tomasini and Van Wassenhove (2004)

Looking back at the characteristics of the disaster relief supply chain most academics agree that Lee's Triple-A framework of agility, adaptability and alignment meets the requirements for an effective supply chain setup.[14] According to Lee, agility is the "*ability to respond to short-term changes in demand or supply quickly and handle external disruptions smoothly*". Furthermore adaptability is the ability to meet structural shifts in markets and alignment relates to the creation of incentives for better performance These three factors have to be met in disaster relief supply chains, because they must be set up and changed quickly under difficult conditions with the different needs and dynamic roles of the many players involved in the operation.

2.2 Challenges and Problems

As we pointed out through the characteristics of a disaster relief supply chain there are many challenges and problems the relief organizations are facing. In this section we want to give an overview of the most common challenges and problems. In the next section institutions that found and introduced solutions for their problems over the last years will be introduced.

Thomas and Rock Kopczak defined the 5 common challenges in disaster relief supply chains[15], which we will examine in this paper. There might be additional challenges for some disasters that we will just describe shortly at the end. These have to be reviewed in other papers due to the limited length of this one.

2.2.1 Lack of Recognition of the Importance of Logistics

Logistics is the major part of disaster relief and therefore accounts for the most expenses of the operations. Accordingly, an effective supply chain setup could reduce expenses and improve the relief operations by far.[16] This improvement would need investments in the infrastructure, systems and

[14] Stapleton et. al (2009)
[15] Thomas and Rock Kopczak (2005)
[16] Thomas and Rock Kopczak (2005)

processes, such as information systems, that would have long-term improving impacts.

Still most funding is used for short-term, direct relief and front-line activities and just a small percentage is allowed for administration. This is not only a mistake by the organizations itself. The donors, private and governmental, want “their money” to have a direct impact on the disaster and not on a long-term help.

But also within the organization, logistics have to be more recognized. Still logisticians are excluded from a lot of decisions, which are done by the front-line staff that controls the budget. E.g., the assessment team, who determines the demand right after a disaster has occurred, often doesn’t include a logistician, who could anticipate and plan bottlenecks that are often necessary for delays in delivery of relief items.[17]

2.2.2 Lack of Professional Staff

Many members and leaders of relief organizations begin their career with a background of social sciences, development studies or law, they want to resolve and do good in the world. They see themselves more as activists than professionals.[18] Within the logistical staff, very few have corporate experience or professional training in logistics, even the staff with higher responsibilities. Their experience and position is achieved by trial and error in multiple disasters they have worked at. A survey revealed that 80% of the responding organizations had staff specializing in logistics and transportation duties, but only 45% had someone with formal qualifications in logistics, transport or related areas.[19]

But expertise from the corporate world and “professionalization” is getting even more important as the humanitarian environment is getting more complex and organizations are struggling to find people who can manage the complex disaster relief supply chains.

[17] ibid
[18] Gustavsson (2003)
[19] Oloruntoba and Gray (2003)

While large organizations realized this need and changed towards a professional logistical department, in general this adaption is going really slow and field experience is still considered much more valuable for logistical experience. But standardized training is slowly implemented in organizations and seen by logisticians as directly linked to the performance on their job.[20]

2.2.3 Inadequate Use of Technology

In the private sector use of technology has been implemented in nearly every category. IT systems are a key factor for global operations inside and in between companies and they helped decision makers to create new ways of efficiencies. In the humanitarian sector, the use of technology is still not common for most relief organizations and their operations.

A survey of the Fritz Institute showed that during the Tsunami in the Indian ocean 2004 just about one out of four logisticians had access to any tracking and tracing software and the majority was still working with manual processes or excel spreadsheets for updates and tracking of goods.[21] In result, nearly half of the respondents stated that they received accurate and timely information about the supply flow.

Also communication systems and the use of the Internet could have a big impact, as the information flow inside an organization and the information flow to other organizations, donors, media and the outside world could be accelerated. This could have a big impact for the front-line workers, who would have on-time data that improves operations in nearly every aspect.[22]

2.2.4 Lack of Institutional Learning

Reflection and the exchange of knowledge is one key factor for the improvement of supply chains and personal improvement. However, in the humanitarian sector this reflection is most of the times not done because aid workers are assigned to the next mission immediately after a crisis is dealt with.

[20] Thomas and Rock Kopczak (2005)
[21] Thomas and Rock Kopczack (2005)
[22] Balcik et. al (2008)

Therefore lessons learned are commonly lost or remain just as a personal experience, which is not given to colleagues or the next generation. Additionally the humanitarian sector has an extreme high turnover rate of field staff. About 33% in average[23] and up to 80% for field logistics leave their job after just one year[24]. This high turnover rate, mostly caused by burnout, lets most experiences be lost, because leaving staff isn't transferring their experience at all.

2.2.5 Limited Collaboration

Already in the 1990s relief organizations realized that multi-agency collaboration is of big importance for the common goal of aiding the relief community as a whole, even if each organization has it's unique goal.[25] But with the emerging competition for funding between relief organizations there is still little collaboration between them.

Even though organizations work hand in hand at some points during an actual disaster response operation, at the strategic level you will find less collaboration. E.g., at the Tsunami 2004 just over half of logisticians reported working with other agencies in setting up their supply chains.[26]

Collaboration could be in form of sharing resources, equipments, knowledge, information or contacts. Additionally organizations could have partnerships in procurement to reach better prices for the supplies or in pre-positioning to share the costs of warehousing.

2.2.6 Additional Challenges

The five common challenges Thomas and Rock Kopczak defined can be extended by a variety of other problems. Here we will just point out a few.

Big problems for organizations are the characteristics of donations. Beside financial donations, that also can cause problems as mentioned before, there are often in-kind donations. When these donations are not handled with care

[23] Gustavsson (2003)
[24] Thomas and Rock Kopczak (2005)
[25] Beamon and Kotleba (2006)
[26] Thomas and Rock Kopczak (2005)

and with fix set criteria, these goods can cause big problems and bottlenecks at the point of arrival or at the warehouses.

A second major challenge is the one of procurement and pre-positioning. According to the unpredictable demand and high costs pre-positioning can just be done in a small dimension. However, multi-national agencies are using pre-positioning at some strategic locations for being faster in disaster response.

Another big problem is caused by political and cultural reasons. Depending on the situation in a region, which might be affected by political or cultural conflicts, or the governmental structure, “foreign” organizations can face problems because they are subjects to the law of the country and bound to the governmental restrictions and willingness to accept aid. E.g., some governments may refuse aid, disallow relief workers to entry the country[27] or the relief workers could face safety problems when battles in the disaster region occur.[28]

2.3 Institutions that face the Challenges

There are many approaches to solve the problems and challenges we just described. Still the best approaches are not just from single relief organizations, they come from institutions that are aiming for single or multiple goals. Here we will present a short look at three institutions and their approaches.

2.3.1 Fritz Institute

From 2003 to 2008, the Fritz Institute hosted the annual Humanitarian Logistics Conference to create a community for professional logistics. The conference gave them the opportunity to share their knowledge and experiences with the aim to increase the recognition of logistics in the humanitarian sector. This conference was the first, and for a long time the only community of it’s kind and has now been followed by other conferences.

[27] Russell (2005)
[28] Balcik et. al (2008)

To take a look at the described challenges this conference helped logistics to get recognition by the entire humanitarian sector as the professional logisticians communicated their needs and thoughts with one voice. Another outcome was the “humanitarian logistics certification program” which teaches and trains principles of supply chain management in different stages to humanitarian logisticians and increases proficiency and expertise. Resulting there were a couple of initiatives and outcomes of this conference that are still running, which can be reviewed on their website.[29]

Anyway, this example shows that professional communities can help to solve the challenges and foster collaboration between agencies, professionals and academics.

2.3.2 Humanitarian Supply Management System

The Humanitarian Supply Management System (SUMA) is a user friendly, easy to install and adaptable computer program that tracks and reports all goods from all parties. Designed as a small management system for medicines in Latin America and the Caribbean, SUMA has been enlarged and designed with inputs from practitioners, governments and emergency management specialists.

The software registers and tracks supplies through all stages of the disaster relief supply chain, from donation to storage and distribution. Through data collection and processing and the exchange over the Internet, SUMA generates reports to inform organizations, donors, media and beneficiaries.

Beside the software SUMA delivers a methodology that helps to label, prioritize, store and distribute goods. The use of this methodology and the software are managed and deployed by FUNDESUMA, an organization that assists in emergencies and trains local teams to be prepared and independent in the event of an emergency.[30] The success of this system was

[29] Fritz Institute (2012)
[30] Tomasini and Van Wassenhove (2004)

seen in many disasters and was the basis for a international software, the "Logistics Support System".[31]

This example shows that adequate use of technology can support and help organizations and logisticians during disaster relief.

2.3.3 United Nations Humanitarian Response Depot

The United Nations Humanitarian Response Depot (UNHRD) is a network of five hubs around the world in strategic locations. These hubs hold stock reserves of emergency relief goods to support authorized relief organizations to respond to emergencies. Managed by the World Food Programme, the UNHRD provides the "*use of the emergency response facilities and associated support services at a no-cost or cost-recovery basis"*.[32]

Through the positioning of the hubs the UNHRD is able to send relief items anywhere in the world within 24-48 hours. With joint procurement, special arrangements with suppliers guarantee the 41 authorized organizations preferential rates for a defined period of time. Other benefits can be seen on the UNHRD website.[33]

This example shows how collaboration and a global umbrella organization can reduce costs and accelerate and improve operations on a global scale. The UNHRD helps in pre-positioning and procurement for relief organizations, which can rely on this partnership and help in emergencies way faster and more cost efficient.

[31] Logistics Support System (2012)
[32] UNHRD (2012)
[33] UNHRD (2012)

3 The Last Mile as a Part of the Disaster Relief Supply Chain

"Last Mile distribution is the final stage of a humanitarian relief chain; it refers to delivery of relief supplies from local distribution centres to beneficiaries affected by disasters".[34] This definition counts for the humanitarian and with minor amendments also for the private sector. But in the environment of a disaster the last mile distribution faces much more challenges and problems.

As mentioned before disaster relief supply chains are complex and dynamic and being the last stage in a dynamic system can cause big problems.

Figure 4 shows a really easy, but typical setup of a disaster relief operation involving international actors.[35]

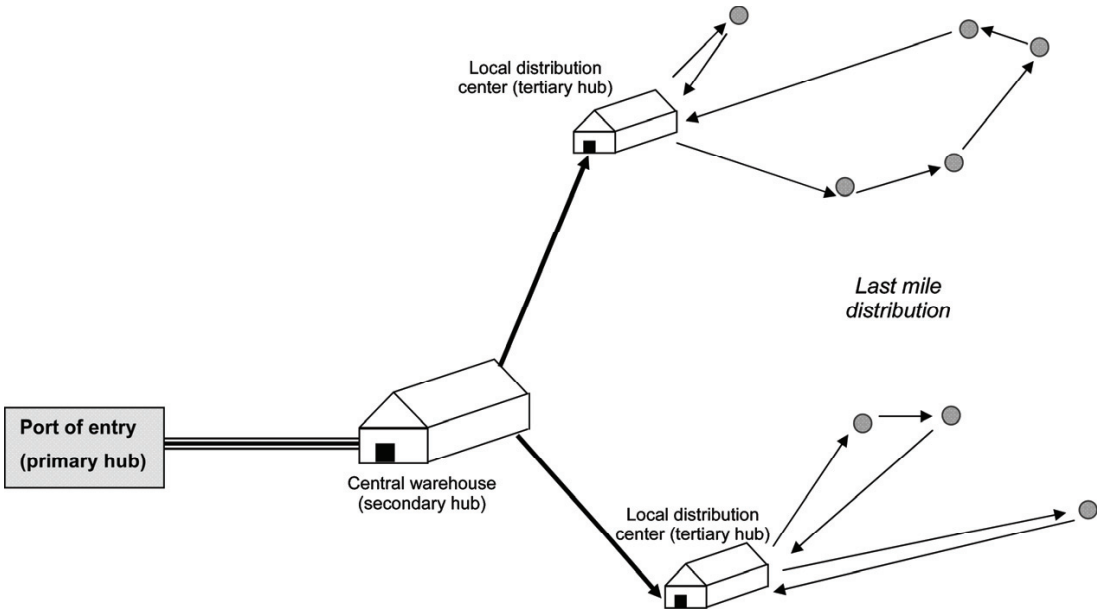

Figure 4 Structure of the relief chain *(Source: UNDP Disaster Management Training Programme modified by Balcik et. al, 2008)*

In this chapter we will give a short overview of the characteristics of the last mile distribution in disaster relief and then point out the four main challenges and problems within these operations.

[34] Balcik et. al(2008)
[35] Balcik et. al (2008)

3.1 Characteristics

The environment of a disaster is a very special one and last mile distribution has to adapt to these unique characteristics. As Balcik puts it, the objective of last mile distribution in disaster relief is to *"minimize the sum of transportation costs and penalty costs for unsatisfied and late-satisfied demand for different types of relief supplies"*.[36] This objective was defined for a mathematic model. But it is very difficult to quantify penalty costs for unsatisfied or late-satisfied demand in disaster relief, as it can mean life or death. Anyway this shows that last mile distribution in disaster relief is about the delivery of the right amount of demand, at the right time to the right place and recipients with a set of vehicles and the objective to save money and resources.

Demand and type of relief items vary greatly by the situation, location and time of a disaster. E.g., is heavy clothing not needed in tropical regions or mosquito nets in cold areas. Impact of the disaster, demographics and social and economical conditions of the area define which supplies are needed. Still it is possible to differentiate between two types of items. First there are the items, where the demand occurs right after the disaster has struck and the following days or maybe weeks. These are emergency supplies like tents, blankets, jerry cans, mosquito nets etc. Secondly there are the items that are consumed regularly over the whole relief operation. Examples are food supplies or hygiene kits.[37]

Even if relief items can be characterized into just two types, in most cases it is still unknown where and when they have to be delivered. This is caused by the unpredictability that is given for a disaster relief last mile distribution system. In the early days of disaster relief operations an initial assessment is done but may not be very reliable.[38] During operations the organizations have to update their assessments but still it is very difficult to get exact information of time and quantities. Additionally the work can be complicated through post-disaster events like aftershocks. Furthermore the planning

[36] ibid

[37] Balcik et. al (2008)

[38] ibid

horizon is unknown for the demand, the supply of relief-items, aid workers and vehicles.[39] As mentioned before, the information flow is not well developed and reliable in the humanitarian sector because of the lack of use of technology. The unpredictability in these different categories makes strategic planning for the last mile very difficult.

But the demand and planning difficulties still depend on the infrastructure of the relief area. In a lot of cases the infrastructure is in a bad condition and relief agencies first have to fix it or even set up a working infrastructure. As Figure 4 showed Local Distribution Centres (LDCs) serve as warehouses and operational knots. Therefore they must be set up at a strategic location that has access to the affected region. Also the type of LDCs can be of importance, as it can be a tent, a prefabricated unit or an existing facility like a school, warehouse, church, etc..[40]

For the case of transportation the condition of the roads define which routes the vehicles can take and also which kind of vehicle can deliver supplies. E.g., small trucks reach areas where roads are not passable for larger trucks. Even worse for the distribution is the case of destroyed bridges or areas that might not be accessible for land-vehicles. In this case transportation must be done by expensive air delivery via helicopter or by airdrops from planes.

In this environment of the last mile distribution logisticians have to make their decision in a short period of time. In practice this leads to the most significant constraints of transportation capacity and supply availability, especially in the early days following a disaster. Actually, most of the manager's operational decisions of last mile distribution are the relief supply allocation, vehicle delivery scheduling and vehicle routing.[41]

3.2 Problems and Challenges

With the characteristics of an unpredictable situation and lack of information there are a lot of problems and challenges the managers of the last mile distribution are facing. Following we will present the three most significant

[39] ibid
[40] Balcik et. al (2008)
[41] Balcik et. al (2008)

logistical problems Balcik presents in his paper[42] and give examples for each of them with an additional problem we think is of big importance.

One of the main characteristics of the last mile distribution in disaster relief is also one of the main challenges. The infrastructure has an impact on every stage of the operations. It defines where the LDCs are positioned. It has an impact on the vehicle routing decision and vehicle fleet, as roads can be damaged and areas might not be accessible. But the infrastructure in a political view has also impacts on the vehicle routing decision, as in hostile areas vehicles might have to travel in convoys due to safety reasons.[43] These challenges can lead to delays of the delivery as planning of vehicle routing and vehicle delivery scheduling depends in various ways on the infrastructure. Most of the problems caused by the infrastructure can be solved by more expensive or complex solutions, but not all organizations can afford them. E.g., are the costs of helicopter operations by far higher compared to the ones of a vehicle fleet.

If infrastructural problems can be solved, another challenge for the vehicle routing and delivery scheduling is caused by insufficient information about demand and the infrastructure itself. Information are necessary for the field workers and especially for the strategic planers of the last mile operations. And there are many situations where a lack of information can cause problems. As mentioned a lack of knowledge about current road conditions influence the vehicle routing plans. In some cases and areas even reliable local maps for general orientation are not easily to get in the days immediately following a disaster.[44] These days are indeed the most critical for information scarcity. As mentioned before, during the early days after the disaster occurred the demand is not completely reliable, as it has been done by a short assessment and the information about supply flow in the supply chain is often not really reliable as well. Information about vehicle statuses of location and timing would help practitioners with monitoring and planning, but

[42] ibid
[43] Balcik et. al (2009)
[44] Balcik et. al (2009)

the technical infrastructure and the tracking and tracing processes used in the humanitarian sector does not provide this data.[45]

Even if infrastructural and information problems can be solved, organizations are still facing limitations related to transportation resources and emergency supplies. As mentioned above the vehicle fleet has to be able to operate in the geographical and disaster affected environment. But especially the facilities of these vehicles can cause problems, as temperature control might be needed for food or medication. Secondly most organizations do not own and operate their own fleet. They often rent vehicles and drivers in the affected countries or areas. This can cause problems if supply does not, or just poorly, exist.

But the transportation itself is not even the main problem as other transportation types can always be used in emergency.[46] The bigger problems are fuel shortages, which can actually develop very quickly due to a lack of fuel-supply or just because the pumping stations run out of power.[47] And fuel shortages are not just occurring in developing countries. Hurricane Katrina in the USA 2005 showed this, as fuel was one of the main supplies demanded for emergency assistance and demand could not always be met.[48]

If the supply chain is working organizations can have big problems with a lack of emergency supplies. There are different reasons for it and supply chain managers are often confronted with the decision if they should procure their supplies locally or internationally.[49] There are advantages and disadvantages for both types of procurement. E.g., local supplies have shorter lead times and lower logistical costs and the local market and economy gets supported. Problematic is that quantity and quality needed might not be available. This is no problem for international procurement, but here the transportation costs are higher and the process for global procurement is really time consuming, as organizations are competing for

[45] Balcik et. al (2008)
[46] Kovács and Spens (2007)
[47] Sullivan (2005)
[48] White House (2006)
[49] Murray (2005)

goods in competitive biddings and additionally custom clearance can slow down the transportation process.

All these problems and challenges could be improved by better coordination among relief actors, but this is still lacking for most objectives. As Rey puts it *"Coordination has continued to be the fundamental weakness of the humanitarian action*".[50] The coordination has improved in the last years with several institutions like the presented UNHRD, which helps the relief organizations for the last mile distribution to have the relief items at the time, they are needed. But still there are a lot of parts that can be optimized for coordination, not just among organization, international and local, but also between the humanitarian sector and the private sector. Examples for coordination topics refer to resource and information sharing, centralized decision making or regional division of tasks.[51] However there is still no single organization with the authority to handle the coordination and the governments that take over this part often have a lack of necessary experience and knowledge.[52] The biggest problem for the relief organizations is that coordination initiatives and meetings cost time and money, in the strategic and tactical pre-disaster levels as well as during the disasters.

[50] Rey (2001)
[51] Balcik et. al (2010)
[52] Balcik et. al(2009)

4 Optimization of Last Mile Distribution in Disaster Areas through Business Approaches

Due to the rise of e-commerce, the last mile has got more and more attention of the private sector during the last years. As Neuborne already noticed in 2000 "*This is the season when the last mile will be the most crucial element of e-business*."[53] As the final stage of the supply chain the last mile distribution is a substantial factor for customer satisfaction and loyalty. But this is not the only fact why big e-commerce and logistic companies paid a lot of attention on the last mile. Due to its structure the last mile is one of the most expensive parts of the entire supply chain, which can account for 13% up to 75% of the total logistics cost.[54] Additionally many logisticians name it as the *"least efficient, most polluting, most important yet problematic part of the supply chain".* These problems are mainly caused by high delivery failure, empty trip rates, lack of a critical mass and the characteristics of the delivery fleet. But as in disaster relief, the last mile has gotten relatively little attention of the academic literature to its specificities and the relevance to innovation.[55] Still there have been practical approaches to make the last mile more efficient and cost effective. In this chapter we are presenting three of the most common approaches of last mile optimization and will discuss, how applicable they are for disaster relief.

4.1 Use of Intelligent Transportation Systems

The movement for the use of Intelligent Transportation Systems (ITS) already started in the early 1980s. The goal of the ITS is to apply modern telecommunication, computer and electronic technologies to the existing transportation systems to improve the logistical efficiency in ways of economy, mobility, safety, air quality and productivity and to reduce congestion.[56] In recent years the use of communication and technology plays a core role for logistic companies. Up-to-date information on vehicle status,

[53] Neuborne (2000)
[54] Onghena (2008)
[55] Gevaers et. al (2010)
[56] Hasan and Yaz (1999)

road and route conditions, supply availability, customer demands, etc. provide opportunities to improve the supply chain in many different ways. E.g., can information about customer demand allow products to be delivered in the most direct way and lower the cost of transportation.[57] Or information about arriving supplies, transportation times and vehicle statuses can allow improving the scheduling and supply allocation decisions.[58] These new technologies are used in various ways in the last mile, be it tracking through Radio Frequency Identifications (RFID) or Barcode Scans for sorting systems at the warehouse or at the point of delivery, the use of Global Positioning Systems (GPS) for routing plans and fleet management or real time information about the traffic to avoid traffic jams.

For disaster relief there is a wide range of application possibilities and improvements through the use of ITS. As mentioned before the flow of information is one critical part in disaster relief and communication technologies can have a big impact on the operations. Only the use of mobile satellite communication system, the Internet and geographical data tools during the Kosovo crisis 1998-1999 in comparison to the use of telephone and radio-based communication at the Somali crisis 1992-1993 opened new possibilities for relief workers.[59] Sargent and Michael also call for the use of ITS and a digital aid framework. For the last mile distribution in disaster relief the use of ITS could support in the following ways:[60]

- Advantages to improve the routing and management of emergency vehicle fleet and operating local relief distribution through monitoring vehicle statuses
- Advantages for vehicle routing decisions through up-to-date information about the transportation network infrastructure
- Advantages of allocation plans through reliable information related to supply movement in the upstream relief chain with supply tracking

[57] Lee and Wang (2001)
[58] Balcik et. al (2008)
[59] Sargent and Michael (2005)
[60] Balcik et. al (2008)

Even if ITS have a lot to offer to improve disaster relief operations, there is a technological infrastructure required for an effective implementation that is limited or nonexistent in many areas or can be affected by the disaster. Still the use of ITS is more and more common in disaster relief and it will get even more attention in the following years, because the technological infrastructure and use of the Internet is getting standard in nearly every part of the world.

4.2 Supplier – Buyer Alliances

The main goal of supplier and buyer alliances, as Anderson and Narus summarized, is: "*the fundamental reason for the relationship-building activities and efforts is to either add value or reduce cost*".[61] Or to say in other words, it's in both parties interest. The alliances can be done in very different ways, but the main ones are quick response, continuous replenishment, vendor managed inventory and consignment inventory.[62] Even if these types of alliances are very different, the main characteristic of each is information sharing between the partners, typically by Electronic Data Interchange. The level of information given out and the control given to the supplier depends on the mechanism chosen. E.g., the supplier gets in a quick response strategy point-of-sale or point of use data from the buyer to synchronize the production and inventory planning. In comparison to the vendor managed inventory these are just a few information. In the strategy of vendor managed inventory the supplier monitors the inventory levels of the buyers and sets the right order quantity and timing. This is a much stronger relationship than the one of quick response, because the supplier has much bigger responsibilities. We can't describe all of these four strategies in detail, but they got analyzed in different articles.[63]

For relief agencies the implementation of a strong supplier-buyer alliance has a big impact on the procurement operations. The main advantage would be that relief organizations could use the suppliers' expertise for procurement. But the implementations of strong alliances are hold back by many reasons. First, in the environment of disaster relief there is, as discussed, limited

[61] Anderson and Narus (1990)
[62] Balcik et. al (2010)
[63] Simchi-Levi et. al (2003)

information technology available. Second, the risk of holding additional supplies is very high for the supplier, as disasters don't occur on a regular basis. Third, the organizations would depend on a single supplier, which is very uncommon, as they control their purchasing decisions on competitive bidding processes. After all, there are some partnerships between organizations, but the suppliers normally don't have authorization in the order process.[64] These partnerships are mainly promises by a supplier to provide relief organizations with supplies for a defined price.[65] The potential of implementation of mechanisms like quick response or vendor managed inventory exist just for large, worldwide operating organizations or umbrella organizations when information technology is present. For example could vendor managed inventory be an interesting topic for the UNHRD we introduced in section 2.3.3. But for smaller, or even local organizations the implementation would have too many problems, requirements and disadvantages for both sides of the alliance.[66]

4.3 Third Party Logistics Providers

Due to the emerging demand for advanced logistics services and to get a competitive advantage, partnerships with third party logistics (3PL) providers became more and more interesting for many companies. These 3PL providers are external companies who manage, control and deliver the logistical activities on behalf of their clients.[67] These providers have expertise in logistics and can execute all parts of the logistics activities, like warehousing, inventory management or transportation.[68] There is no single definition about the 3PL, but most of the literature suggests that 3PL "*includes any form of outsourcing of logistics activities previously performed 'in-house'*".[69]

[64] Balcik et. al (2010)
[65] Balcik and Beamon (2008b)
[66] Balcik et. al (2010)
[67] Hertz and Alfredsson (2002)
[68] Berglund (2000)
[68] Balcik et. al (2010)
[69] Marasco (2008)

Like in the supplier – buyer alliance the use of 3PL providers needs to be within a close relationship, where demand information must be passed on to the provider. So it can also be seen as a strategic partnership, where both sides have advantages. Some of these advantages are improvement of economies of scale, efficiency of operations, faster learning and many others.[70]

For the humanitarian sector the use of 3PL providers has a potential of implementation, especially in the transportation aspect. World Vision International for example has no international transportation capacity and purchases all transportation resources from 3PL providers.[71] As we already described, a lot of organizations also don't have their own vehicle fleet and hire it from local providers, which could be seen as an early form of 3PL.

But as in the supplier – buyer alliance these partnerships with global 3PL providers can just be done by international organizations, as it is a strategic partnership. Umbrella organizations however can provide the services through these partnerships even for smaller organizations. An example for this is the partnership of TNT, a global leading logistical company for mail and express delivery, and the World Food programme, where TNT provides logistical assistance and improved supply chain methodologies to improve the efficiency of the organization.[72]

[70] Andersson (1997)
[71] Balcik et. al (2007)
[72] Van Wassenhove (2006)

5 Conclusion and Perspectives

The field of disaster relief operations is still relatively new and there is little research done on the special characteristics of a disaster relief supply chain. Over the last few years there have been several disasters with worldwide public attention, which forced relief organizations to focus on the logistical improvements of their operations.

Still there are many challenges and problems in the humanitarian sector that make disaster relief such difficult operations for relief organizations. This paper provides an overview of the special characteristics of a disaster relief supply chain and presents five main challenges of disaster relief operations. Some solutions have been introduced through the work of global institutions.

The second part of the paper introduces the last mile distribution as the last part of a disaster relief supply chain and gives an overview of the four main challenges and problems in the fields of the infrastructure, transportation, coordination and information. Searching for solutions, this paper examines three approaches of the private sector and proves the applicability for disaster relief. As a result we found out that the use of Third Party Logistic providers and the use of Intelligent Transportation Systems provide big opportunities for the humanitarian sector, however, if implemented in the right way. On the contrary the use of supplier – buyer alliances can be very difficult. In any case the adaption of private sector approaches is much easier and preferable for big, international organizations rather than smaller, local organizations.

On account of the length of this paper and the depth of the disaster relief sector, there are many more approaches the private sector takes that can be observed as possible improvements for disaster relief operations. Furthermore, research on this topic is necessary to develop new and innovative ways of improvements. Therefore the disaster relief sector needs more academic research through mathematical and computational experiments to examine frameworks and models that are needed. But even

more important are practical solutions that also can be used by field workers and not just logistical experts with corporate experiences. These practical solutions should be tested on a smaller disaster to prove their practicability, and then rolled out on a larger scale, like it was done with the SUMA project.

However, the improvements over the past few years and the disasters themselves have shown that the importance of logistics has been noticed in the humanitarian sector. The organizations and institutions are on the right path, but they need enhanced support by their donators to get disaster relief supply chains and the last mile distribution more effective and efficient.

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Appendix

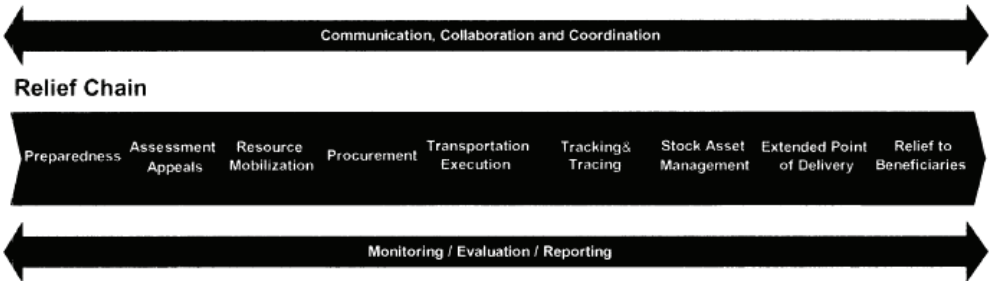

Figure 5 Relief Chain *(Source: Thomas modified by Mizushima, 2004)*

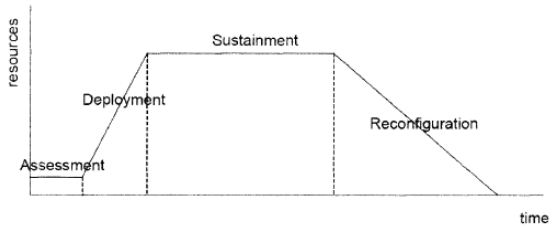

Figure 6 Relief Operation Life Cycle *(Source: Beamon, 2004)*

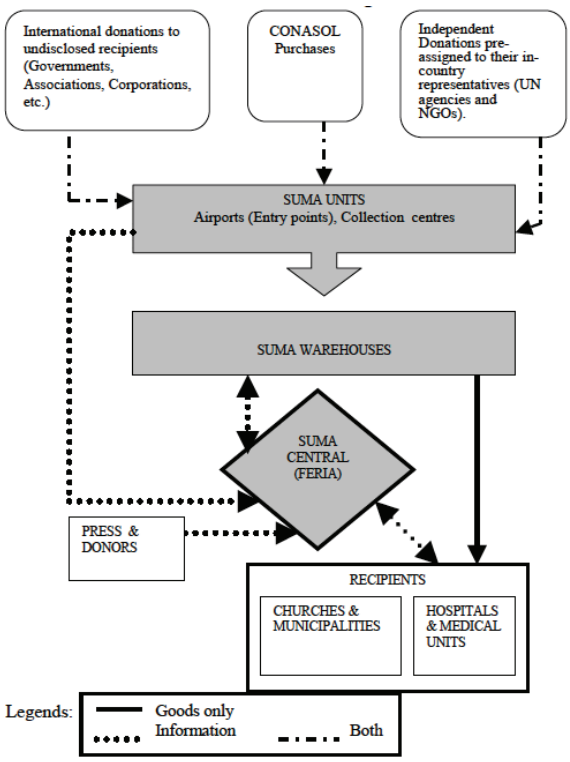

Figure 7 Flow Chart of Information and Goods Registered into SUMA *(Source: Tomasini and Van Wassenhove, 2003)*