# Mobilizing Project-Driven Supply Chains in the Chemical Industry

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**Abstract**

The company sponsoring our project is a leading chemical manufacturer, supplying a wide range of products on a global scale. One of the most interesting lines of business the company operates is to supply specialty chemicals in faraway places on few weeks' notice. The nature of these supply chains is project-driven, or, in other words, unique, non-repeatable and established for the sole purpose of fulfilling a single project. The company faces the challenge of operationalizing the set-up of such supply chains in order to reduce the amount of time and effort devoted to each supply and maximize learning from each project. This thesis seeks to address the conundrum of setting up project-driven supply chains in a more efficient, effective and easily repeatable way. Through interviews with company personnel, we identify eleven challenges and subdivide them into three categories: Business-Specific, Cross-Border, and Last-Leg. Next, through literature review and interviews with experts, we identify seventeen possible solutions to the above issues, which have the potential to improve planning and execution of project-driven supply chains in the chemical industry. Recognizing that cross-learnings from supply chains in humanitarian and military supply chains are valuable, our interviews include military and humanitarian practitioners, with the aim of increasing the variety of solutions. Using the research data as a basis, we formulate a project-driven supply chain mobilization template aimed at including most critical areas required in setting up project-driven supply chains. This template could be used as both a guideline for planning the mobilization of a supply contract, and as a validation tool to confirm the mobilization process has been thoroughly completed. The adoption of the mobilization template and process via integration with managerial and approval processes is expected to drive a more efficient and effective mobilization of project-driven supply chains for companies within the chemical industry and beyond.

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***From both of us***

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***On behalf of Sze Xin Mok***

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## 1. Introduction

The company sponsoring our project is a leading chemical manufacturer and, as such, supplies a wide range of products on a global scale. This large footprint involves a multitude of customers, and, due to differences in geography, culture and customer requirements, requires multiple ways of conducting business.

One of the most interesting lines of business the company operates is to supply specialty chemicals in faraway places on very short notice (such as a few weeks). The nature of these supply contracts is *project-driven*, or, in other words, unique, non-repeatable and established for the sole purpose of fulfilling a single project. Although project-driven supply chains constitute less than 5% of the company's business, the demanding requirements in terms of location, volume and compliance dictated by the nature of the chemical industry generate an extensive amount of setup required on each occasion. The resulting supply chains must balance all the above factors with a setup that will be only utilized *once*.

The sponsor company faces the challenge of operationalizing the setup of such supply chains in a way that reduces the amount of time and effort devoted to each supply, while continually learning from each project. This *niche* area of supply chain management (based on the lack of extensive published research on the subject) is seen as having high potential for growth due to the little attention it has received in the past.

The above scenario raises the main question of our thesis (*RQ1*), which we state as follows:

*RQ1.* *How can project-driven supply chains in the chemical industry be setup in a more efficient, effective and easily repeatable way?*

Naturally, the question stated above raises additional questions, including the following:

*RQ2.* *What are the critical factors in setting up a project-driven supply chain in the chemical industry?*

*RQ3.* *How are project-driven supply chains currently managed within the sponsor company?*

*RQ4.* *How are project-driven (or other one-off) supply chains managed in other fields?*

In this thesis, we attempt to answer these questions through (i) a review of the relevant literature, and (ii) interviews with practitioners from fields with similar characteristics and constraints. A brief summary of the literature that we have reviewed is provided in Chapter 2. An outline of the methodology we followed in this thesis is presented in Chapter 3.

Since helping the sponsor company with their project-driven supply chains is the main driver of our research, in Chapter 4 we identify and categorize the specific issues facing project-driven supply chains and provide a justification of why military and humanitarian supply chains constitute useful additional sources of information. We then look at possible solutions to these issues that have been previously developed within the sponsor company, and in humanitarian and military supply chains, in Chapters 5, 6 and 7.

In our final Chapters, 8 and 9, we discuss the relevant findings distilled from the above process and recommend a series of guidelines aimed at enhancing the mobilization process for project-driven supply chains within the sponsor company. The final chapters also attempt to identify the key factors behind repeatability and cost-effectiveness of project-driven supply chains across multiple case studies, including but not limited to questions such as:

- *Whether any of the existing supply chain organizations within the company could be leveraged to improve response time and costs; and*
- *Whether the company could apply any repeatable method in order to achieve the above objectives consistently.*

We recognize defining a mobilization strategy for project-driven supply chains in the chemical industry is a *complex* problem. As in the scenario highlighted by Perez-Franco (2016, pp. 11-12), we have limited facts to define our desired outcome and few predefined criteria to predict and evaluate the outcome itself.

Accordingly, we use the definition of *repeatability* provided by Zook and Allen (2011, p. 23) as the key criterion to represent a successful outcome for this project. This is defined as the ability of a company to

gain a competitive advantage by differentiating its strategy and generating easy to use guidelines, which allow the business to achieve a faster learning curve than its competitors.

We prefer the term *repeatability* to *standardization*, as the latter raises the practical issue of which organizational elements, markets and functions across business units should be standardized (Cottrill, 2011). This issue should be addressed by subsequent or parallel studies.

We hope our research not only benefits the sponsor company by reducing the current time and effort spent in mobilizing project-driven supply chains, but also initiates an academic discussion towards introducing repeatability to such an interesting yet previously neglected field of supply chain management.

### 1.1 Overview of project-driven supply chains within the sponsor company

The sponsor company has a very large, global footprint, which encompasses several types of supply chains. From a strategic standpoint, the company has made the decision to categorize its supply chains in a selected number of models, one of which is project-driven. The focus of this paper is to explore the project-driven model from the perspective of multiple scenarios the sponsoring company currently faces.

Examples of past projects the sponsoring company has delivered include: (1) the supply of salt components to large-scale solar thermal power plants under constructions in remote regions; (2) the delivery of chemicals required to support a wide range of clients in the mining and oilfield business; and (3) the supply of specialty chemicals to support mega-construction projects.

The critical factors affecting each of the above examples can be summarized as follows:

(1) *Solar-thermal power plants: timing, safety and supply chain design.*

Solar thermal power plants can be classified as special mega-construction projects carrying additional requirements, as the whole supply of salt components is required to happen within a very narrow time window. The timing of the supply is affected by the progress of the construction and hence is subject

to potential delays. In addition, the salts are considered hazardous materials, and as such have specific handling and storage requirements.

(2) *Mining and oilfield operations: variability in demand, seasonality and extreme weather conditions.* Mining and oilfield operations can be highly seasonal businesses, in which clients may submit multiple orders differing in size and required delivery timing in accordance with the performance achieved in the drilling process. As client operations range from off-shore drilling in the Gulf of Mexico to mining in Alaska, extreme weather conditions may affect the effectiveness of the supply.

*(3) Construction mega-projects: competition, customer specifications and cost-effectiveness.* Construction mega-projects are commissioned worldwide and often include unprecedented engineering requirements, which translate in very restrictive customer specifications. The global competitive environment also forces suppliers to achieve unprecedented levels of efficiency in order to be on top of a growing competitor base.

This research focuses on identifying project-driven supply chain best practices and providing guidelines for their application to the above scenarios.

## 2. Literature review

An initial literature search into project-driven supply chains in the chemical industry revealed a lack of high-level, strategic frameworks to address them. Since project-driven supply chains exist in a variety of contexts and industries, we shifted our literature search to other areas.

We found some interesting models and other content in the literature of two specific industry areas, namely construction and yacht-building. Both areas are characterized by high concentration of project-based activities. Nevertheless, the results of our literature search – even including these two areas – were limited in quantity and applicability to our study.

Our literature search then expanded into the fields of humanitarian and military supply chains, based on the recognition that the one-off and temporary nature of supply chain operations in these fields resembled somewhat that of project-driven supply chains.

We proceed to briefly summarize our literature research in the sections below.

### 2.1 Commercial large scale supply chain models

Traditional commercial or industrial supply chain processes present stark differences with project-driven supply chains. Specifically, incompatibility between lean and agile supply chain strategies (which are two common traditional commerical supply chain models) and project-driven supplies is highlighted by Naylor, Naim, and Berry (1999).

The unique nature of each project-driven supply would prevent lean production at the source, i.e. the factory, as the factory would only be operational for a few months at a time with no guarantee of a steady flow of incoming orders. Furthermore, agile supply chain setup requiring pre-existing structures would also be hindered given that material flow need redesigning for each supply.

Aloini, Dulmin, Mininno, and Ponticelli (2015) in fact state that "project industries substantially differ from the stable and continuous supply chains within "goods and service" sector for a number of specific

characteristics: the high complexity and uncertainty in which the production system operates (Fearne & Fowler, 2006); the transitory site configuration managed by temporary supply chain network (Turner & Müller, 2003); the high customer influence on the final product (Pesämaa, Eriksson, & Hair, 2009); the process fragmentation (Baiden, Price, & Dainty, 2006); and the complex network of stakeholders, which involves multiple organizations and relationships (Xue, Li, Shen, & Wang, 2005). These peculiarities together with a number of cultural factors (Love, Irani, & Edwards, 2004) jeopardize the management of relationships between the SC members and are charged to be the rooting causes of the failure to replicate the positive experiences from other sectors."

## 2.2 Specific areas in commercial project based supply chains

Research done in specific industry areas such as construction and shipbuilding has highlighted industry and project specific methods of enhancing project-driven supply chains. Examples we found include case studies in the construction industry (Gadde & Dubois, 2010; Vrijhoef & Koskela, 2000), and in the airport infrastructure construction (Brady, 2011; Potts, 2009). There is also a case study of the yacht-building industry, in which Aloini et al. (2015) identify sixteen antecedents of project driven supply chains and apply them as best practices to a yacht-building company.

However, these case studies were limited in their ability provide solutions for our questions. Gadde and Dubois (2010) focused on efficient partnering between the construction company and its suppliers with solutions in terms of competitive tendering and decentralization. Vrijhoef and Koskela (2000) looked mainly at the reduction of waste through the construction industry. Potts (2009) and Brady (2011) focused on processes integral to supporting the set-up of the London Heathrow Terminal 4, including setting up on-site distribution centers and closer relationship with their suppliers. The sponsor company had no issues with regular suppliers or waste, and was instead faced with time constraints, unfamiliar locale and production capacity issues among others.

It is thus our opinion that these case studies, while highly informative, could not provide solutions directly addressing our sponsor company's issues due to being specific to the company and the industry at hand. Aloini et al. (2015) themselves acknowledge that, due to the specificity of the yacht industry and also limitations in the bias of the interviews, further investigation is required before these lessons can be extended to other project-based industries.

### 2.3 Other project-driven supply chains

Although they are not described as such in the literature, humanitarian and military supply chains are, in essence, project-driven supply chains. This aspect is discussed further in Chapter 4. Our review has found studies seldom call for recognizing or advocating cross-learnings from the humanitarian and military supply chains for commercial project driven supply chains. Most of the literature advocates that humanitarian and military supply chain practitioners learn from commercial supply chains (Tatham and Hughes, 2011; Moore and Taylor, 2011).

A short overview of the humanitarian and military supply chain literature is included in the next two sections. However, in order to consolidate all potential solutions derived from the humanitarian and military supply chains and explain how they link to the relevant issues of the sponsor companies, we later integrate the relevant material from literature with interviews with humanitarian and military experts. These are further elaborated on in Chapters 5, 6 and 7.

### 2.4 Military supply chains

Armed forces are often considered as the inventors of logistics, going back to Roman times. The first formal definition of logistics also involves the movement of armies:

> *Logistics is the art of moving armies. It comprises the order and details of marches and camps, and of quartering and supplying troops; in a word, it is the execution of strategic and tactical enterprises* (Jomini, 1862, p. 62).

The U.S. Department of the Army (2014a) defines the military supply chain as a "distribution process":

> *Distribution is a critical aspect of sustainment which builds and maintains combat power and provides the Army its operational reach. It is the integration of the logistics functions of transportation and supply and is dependent on movement control and materiel management. A well planned distribution system enables support to multiple areas of operations (AO) within a theater. It encompasses the movement of personnel, cargo, and equipment in support of decisive action tasks.*

*Distribution* is a key concept in contemporary military logistics, as effective distribution is deemed critical to maintaining combat power within a continuously changing environment. Consequently, army logistics and distribution processes consist of a clearly defined set of required steps, of which impeccable execution is key to success (Department of the Army, 2014a).

*Preparation* is another key element in military logistics principles. This is often carried out off the battlefield and includes a clear definition of roles and responsibilities, extensive training and a large amount of upfront contracting activities with private and public entities worldwide (Henderson, 2008).

A summary of common military supply chain terminology is reported in Table 1.

*Table 1 - Military supply chain terminology*

| Name | Definition |
|---|---|
| Battle Rhythm (or "Rhythm") | *The synchronization of logistical activities and processes in their support of tactical operations* (Henderson, 2008) |
| Theater of Operation (or "Theater") | *An area required to conduct or support specific combat operations* (Department of the Army, 2014a) |
| Theater Distribution (or "Distribution") | *Organizations and processes for providing materiel to Army forces, other Services, and multinational partners across a theater of operation* (Department of the Army, 2014a) |

## 2.5 Humanitarian supply chains

Humanitarian logistics can be defined as:

> *The process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people. The function encompasses a range of activities including preparedness, planning, procurement, transport, warehousing, tracking and tracing and customs clearance (Thomas & Kopczak, 2005).*

The characteristics of a humanitarian supply chain include ambiguous objectives, limited resources, high uncertainty, urgency, and politicized environments.

While acknowledging that disasters vary and thus require different response types, all disaster responses have three distinct stages: ramp-up, sustain, and ramp-down. The ramp-up stage covers the first few days, in which agencies race to access the disaster area and set up operations quickly. During the sustain stage, agencies focus on implementing their programs. In the ramp-down stage, agencies will be exiting the disaster site. Given the nature of humanitarian supply chains (for acute emergencies), speed of reaction would often be the main driver, particularly in the ramp-up stage. Accordingly, lead-time reduction becomes an important area of consideration.

The key to these organizations efficiently functioning strongly depends on *preparation*, including the availability of *guidelines* for decision-making, *predefined storage* areas and locations, *partnerships* across different sectors, and a structured *communication system* (Goentzel & Spens, 2011). Emphasis should also be given to embracing different cultures within the organization and the local area of operation, as the effectiveness of the last-mile delivery (defined as the portion of transit from the final delivery center to the disaster location) often relies on support provided by local authorities and volunteers (Tomasini & Van Wassenhove, 2009).

## 2.6 Collaboration between military and humanitarian supply chain capabilities

Humanitarian organizations follow, in general, four basic principles of action: humanity, neutrality, impartiality, and independence. These principles are, in essence, *basic* rules of engagement for NGOs. These principles also complicate cooperation between military and humanitarian organizations, as humanitarian aid organizations "fear most of all the loss from being associated with Western military units and their associated political agenda" (Seipel & Heaslip 2014).

Despite this concern, there are many successful cases of military involvement in disaster relief to various extents, such as US military involvement in Haiti in 2010, and NATO deployment to Macedonia, Albania, and Kosovo in 1999. Specifically in large-scale disasters, it is inevitable that the national army of the affected country would be mobilized. As Pettit and Beresford (2005) point out "the nature of a particular disaster or emergency largely determines the form of the response and the mix of military and non-military resource allocation".

## 2.7 Collaboration between military and commercial supply chain capabilities

Commercial supply chain pillars such as inventory reduction, increased reliance on technology, and strategic outsourcing have been identified as critical for the improvement of military supply chains (Leiphart, 2001), drawing attention to the potential knowledge transfer from commercial to military supply chains.

Conversely, opportunities for commercial improvements also abound. For example, military and commercial technology could be combined in order to develop unified communication methods and forge innovative collaboration strategies (Carr, 2009). Overlooking such considerations in a commercial environment leads to a myopic vision of overall supply chain performance, posing limits to improvements.

### 2.8 Collaboration between humanitarian and commercial supply chain capabilities

Some of the literature has focused on improving the effectiveness of cooperation between humanitarian and commercial organizations. According to the literature, this collaboration is complicated by the significant differences in their operating priorities. Humanitarian supply chains clearly differ from commercial ones because of ambiguous objectives, limited human and capital resources, high levels of uncertainty, and the politicized environment, as mentioned above. When TNT's CEO Peter Bakker was asked what he had learned two years into the partnership with U.N. World Food Program (WFP), he replied "businesses are not humanitarian agencies" (Tomasini & Van Wassenhove, 2009).

That said, despite these differences, private-humanitarian partnerships have increased in recent years. The reasons, as illustrated by Tomasini and Wassenhove (2009), are that humanitarian organizations recognize that the private sector has resources and expertise, while in the private sector, there is a rise in the importance of Corporate Social Responsibility (CSR). Beyond giving donations, companies are now increasingly interested in short term relief actions and even longer term disaster response partnerships with the humanitarian sector. Given these intentions, it is likely that the trend of private-humanitarian partnerships will continue.

### 2.9 Collaboration efforts among all three fields

Cross (2014) highlights a recent forum in Sydney discussing the supply chain's role in supporting humanitarian relief – one of the first times such a diverse group has gathered to discuss on this topic. There were representatives from humanitarian and military organizations, like Australian Red Cross and the Australian Defence Forces, commercial organizations that support humanitarian aid delivery, academics researching humanitarian and development logistics, interested private sector companies, and supply chain consultants. More such seminars and discussion would definitely improve cross-sector learning and collaboration.

In the next section, we will highlight the similarities between military and humanitarian events-driven supply chains and commercial project driven supply chains, and the possible value that cross-learnings between these specific types of supply chains could bring.

## 3. Methodology

As previously shared, the aim of this thesis is to improve the execution of commercial project-driven supply chains in the chemical industry, specifically those within the sponsor company. The specific outcome of the thesis is to distil a series of best practices and a series of mobilization guidelines that may improve the performance of project-driven supply chains.

We hope to achieve our objective through the iterative research steps as illustrated in this chapter, using data sources from literature review and interviews.

### 3.1 Selecting a methodology

The methodology of this thesis is constructed to address two constraints and achieve one objective. The two constraints that the thesis faced are:

(i) *Limited sponsor company data* – the methodology is designed to allow for collection of data across a wide spectrum of variables.

(ii) *Exploratory nature of the thesis* – the methodology should enable the thesis to achieve improved understanding of the problem *before* conceptualization of the problem and its measurement as the issues being discussed are in the exploratory phase, as shown in Figure 1 below. Data collected are qualitative and meant to explore different aspects of the questions raised in Chapter 1.

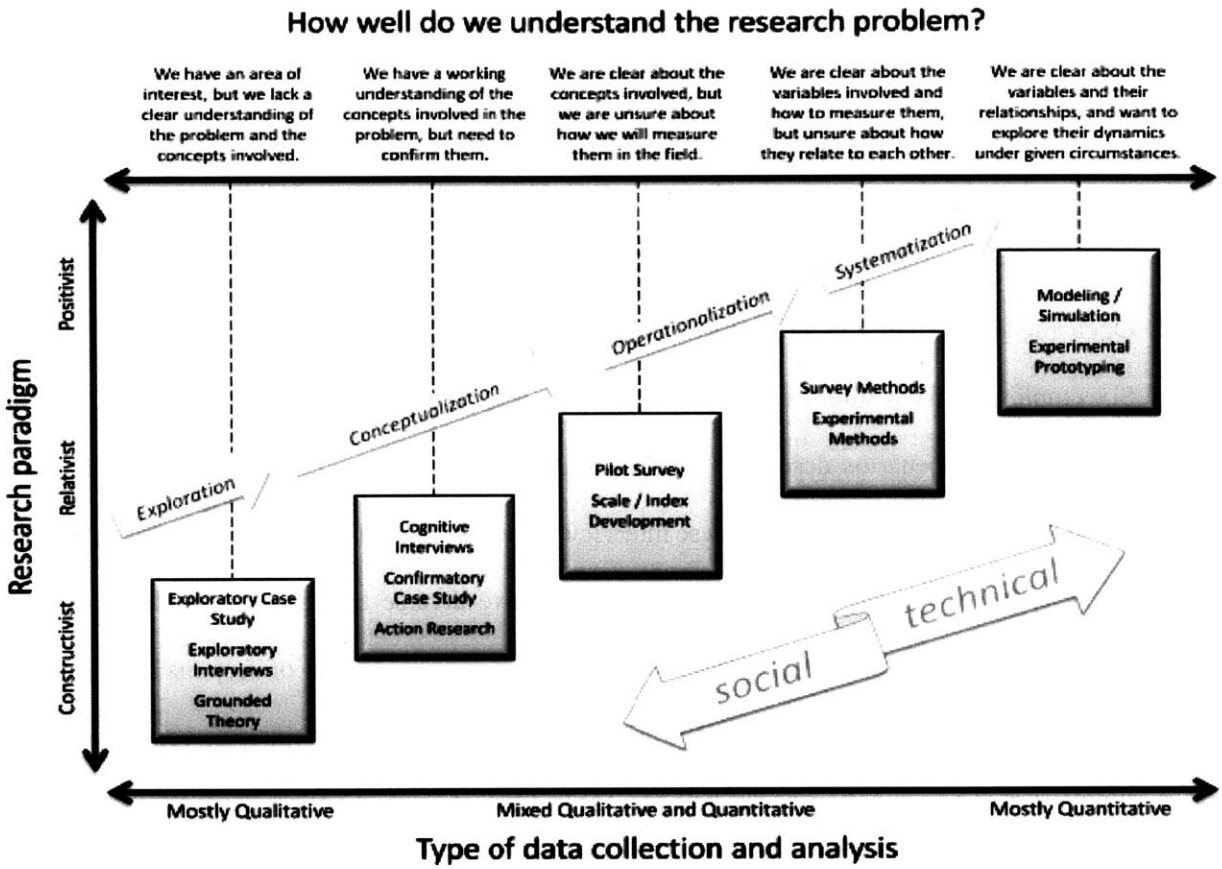


*Figure 1 - Guide for selection of research method. Source: Perez-Franco (2012)*

The thesis aims to be *action-focused.* The methodology is thus designed to deliver a set of applicable guidelines to be tested in the field by the sponsor company and external practitioners. The research would not conclude with just a theoretical explanation of the issues at stake.

### 3.2 Data sources

The research in this thesis relies on the combination of three sources of data:

- <u>Scholarly articles and peer-reviewed publications</u>

  Reputable publications in the fields of commercial, humanitarian and military supply chains were reviewed with specific focus on the following:

  - commercial development of project-driven supply chains,
  - past examples of project-driven supply chains,

- performance indicators of project-driven supply chains,
- humanitarian definitions of event-driven supply chains and relationship to commercial supply chains,
- definition of military supply chains and relationship to commercial supply chains, and
- case examples of cooperation amongst the three fields.

- Open and semi-structured interviews of sponsor company personnel

  Six employees from three distinct business units of the sponsor company (mirroring the three company case scenarios described in the introduction) were interviewed following the protocol described later on in this section. These interviewees were selected based on direct recommendation of the sponsor company. While the employees have diverse backgrounds, including different geography of operations of their business units, seniority, and level of responsibility, all share present and past exposure to project-driven supply chains. These interviewees shall remain anonymous. Their experiences are listed in Table 2 below.

*Table 2 - Interviewee list, sponsor company*

| # | *Experience* |
|---|---|
| 1 | Procurement, Transport Solutions |
| 2 | Head of Supply Chain Management |
| 3 | Supply Chain, Import |
| 4 | Order and Inventory Management Lead |
| 5 | Transportation and Distribution Manager |
| 6 | Business Manager |

- Open and semi-structured interviews of experts from humanitarian, military and commercial supply chains, external to the sponsor company

  Fourteen academics and practitioners from the humanitarian, commercial and military fields were interviewed following the interview protocol described in a later section. These interviewees were

selected based on direct recommendation from the MIT Center for Transportation and Logistics (CTL) for humanitarian and military experts, and follow-on introductions of additional candidates based on discussion with early interviewees.

The *commercial expert* was recommended by the sponsor company, given his wide-ranging twenty years of experience planning and implementing commercial supply chains of all types. The fictitious name of Antiguo was assigned for preservation of anonymity.

The *humanitarian interviewees* and their experiences are reported in Table 3 below. The interviewees were assigned fictitious names to guarantee anonymity.

*Table 3 - Interviewee list, humanitarian*

| # | Name | Experience |
|---|---|---|
| 1 | Ursa | Post-doctoral associate in operational research, research interests include disasters in Mexico |
| 2 | Rory | Head of Logistics of a government emergency disaster response organization |
| 3 | Preto | Former U.N. World Food Program (WFP) Resource Management and Demand Planning Manager |
| 4 | Mariano | Assistant professor in a US university with research interests in operations and supply chain management in disaster response |
| 5 | Neruda & Mistral | Two associate researchers of the National Research Center for Natural Disaster Management in Latin America |
| 6 | Protos | Former World Bank officer, with 3-4 year experience in South Pacific countries. |

The *military supply chain interviewees* and their experiences are reported in Table 4 below. Fictitious names are used to preserve anonymity. All interviewees have U.S. Armed Forces backgrounds. This is due to MIT CTL's connections with logistics experts from the U.S. Army. This means that U.S. Armed Forces model of supply chain planning and implementation has been considered as the standard military supply chain for the purposes of this thesis. While we acknowledge that there are many differences in the logistics methodology of different countries

and armies, we believe that the above assumption is reasonable given that the U.S. Army is the main armed force in the world in terms of impact.

*Table 4 - Interviewee list, military*

| # | Name | Experience |
|---|---|---|
| 1 | Brandon | Logistics Officer, Marine Corps (Former) |
| 2 | Brian | Helicopter Team Leader, U.S. Army (Former) |
| 3 | Heath | Production Lead & Inventory Manager, U.S. Army TACOM LCMC (Former) |
| 4 | Ethan | Junior Officer, U.S. Navy (Former) |
| 5 | Christian | LTC, U.S. Army |
| 6 | Craig | LTC, U.S. Army |
| 7 | Tom | LTC, U.S. Army |

### 3.3 Data confidentiality specific to interviews

Since this thesis is to become a public document, the name of the sponsor company is withheld, and other sensitive details are kept confidential. We have guaranteed all interview participants the preservation of their anonymity, to ensure their voluntary, honest, and unbiased contributions. Except as required to fulfill the above conditions, the data presented in this research is free from manipulation.

### 3.4 Research steps

Our research followed a series of four steps, described below and summarized in Figure 2. The steps follow an iterative process. In qualitative research, it is deemed beneficial to refine the data collection strategy based on the quality and quantity of information collected during early interviews, and to capitalize on opportunities to access more interviewees as the interview process unfolds (a process known as 'snowballing') (Seidman, 2006, pp. 54-55). This is the main justification for having multiple iterations.

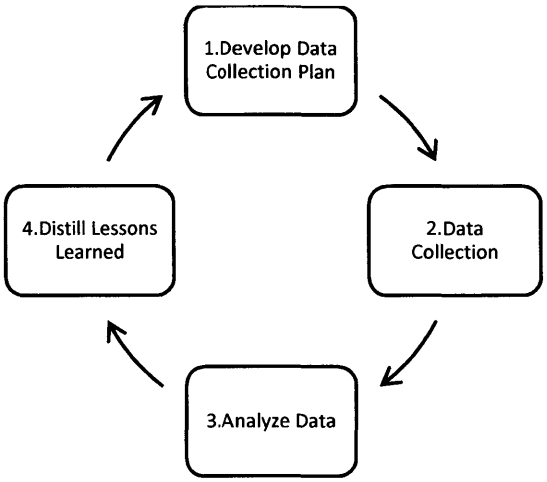


*Figure 2 - Research steps*

1. Develop data collection plan

   Data collection is based on the three data sources detailed in the earlier section. Since a large part of data collection stemmed from interviews, an interview protocol was developed to ensure data collection would address the two thesis constraints illustrated in the earlier section, namely need to expand data sources due to limited sponsor company data and exploratory nature of the thesis.

   The interview protocol defines the questions, timeframe and interviewer conduct during all interviews. Given the highly qualitative nature of data, the adopted protocol follows the combination of a brief series of positioning questions (~5 minutes), an open section (~25 minutes), and a semi-structured section (~15 minutes) for a total of about 45 minutes. The structure mirrors the guidelines by Rubin and Rubin (2005, pp. 134-146), who recommend a combination of "Main Questions, Follow-up Questions and Probes" and is designed to evoke richness by "encouraging the interviewee to elaborate" without forcing a static structure.

2. Data collection

   Using the designed interview protocol, twenty interviews were conducted. All interviews were conducted either on the phone or in person by one or both researchers and recorded with the

consent of the interviewee. A sample of questions used in different sections of the interview protocol is reported in Table 5 below.

*Table 5 – Samples of interview questions*

Samples of interview questions for the different sections within the interview protocol used, are as follows:

*Positioning questions (~5 minutes):*

a. How long have you been in your current position?

b. What are the responsibilities of your current position?

c. What were you doing before?

d. How many years of experience do you have in logistics/supply chain?

*Open section (~25 minutes):*

Can you share an example of a project-driven (one-off) supply chain from your past experience?

a. What was the project about?

b. How did you and your team go about setting up the supply chain?

c. Did you use any tools or methods to assist in setting up the supply chain?

d. What were the requirements in setting such a supply chain?

e. Would you say the supply chain achieved its goals?

f. What went well?

g. What did not go as well?

h. What do you see as opportunities to improve the execution of the supply chain?

i. What are some of the lessons learned from this project?

*Semi-structured section (~15 minutes):*

Two or three additional questions based on the interviewee's previous responses. Common questions involved level of cooperation with the other sectors, leveraging existing resources within the organization and commenting on suggestions made by other interviewees.

Data was also collected through literature. As this is an iterative process, further data collection from all three data sources snowballed through recommendations.

3. Data analysis

   The data collected from both the interviews and literature were organized in a case-study structure and analyzed following the principles of cross-case analysis as described by Stake (2013, pp. 46-77). A list of key themes was developed for each case, after which multiple common themes were collected in a table. Cases were rated according to the expected utility of each case for each theme. Finally, assertions and recommendations were made based on merged findings and triangulation across cases yielding a list of assertions for each theme.

   The process was first performed individually for military, humanitarian, commercial and sponsor company data, then repeated to cross check for common themes across commercial, military and humanitarian data that were specifically relevant to the specific company challenges and issues. Interview recordings and subsequent data analysis and cross-checking were processed by both researchers to ensure consistency.

4. Lessons learned

   The identified common themes and related specific learnings and recommendations derived from the data analysis process were recorded. Gaps identified or recommendations for further research would be taken into account beginning from Step 1.

### 3.5 Research application

The above steps allowed us to generate a set of recommendations based on the combination of the sponsor company, military and humanitarian data. The recommendations are then fed back to the sponsor company for test application spanning all business units involved with project-driven supply chains via this thesis. The list is meant to be dynamic, so as to drive change and innovation in the business units operating project-driven supply chains, within the sponsor company. A further revision of these recommendations is encouraged following a period of application and further collection of field data.

### 3.6 Limitations

The methodology of our choice does have some limitations, due to our reliance on qualitative research:

- Lack of quantitative backing of recommendations; this can be considered as a successive step in the research, once the guidelines have been implemented and more data is available.
- Non-guarantee of data optimality; interviewees being selected based on direct recommendation is no guarantee that they will be the most qualified interviewee candidates. This can be addressed in a successive step by issuing a pilot survey to a large sample population, once the initial understanding of the problem has been clarified. This item is not covered due to the scope and short time period of this research

Both of the above listed limitations can be addressed by extending the scope of this study beyond what was envisaged and feasible for us to perform. We hereby invite the sponsor company and any researchers to use this paper as the starting point to move the knowledge forward on this captivating subject.

## 4. Project-driven supply chains within the sponsor company

Project-driven supply chains are crucial in supporting niche business operations within the sponsor company. This has thus incited a desire within the sponsor company to investigate and study the elements of such supply chains. This chapter has three purposes. The first is to provide an overview of project-driven supply chain within the company, and to outline its general challenges. Second, this chapter lists in more detail the specific challenges faced by project-driven supply chains. And third, this chapter compares the company's project-driven supply chains with other one-off supply chains in the humanitarian and military areas.

Our intent is to look critically at the experiences that our sponsor company has had with project-driven supply chains, and to distill the key *challenges* and *learnings* that can be gleaned from these experiences for possible application across the sponsor company. The challenges are discussed in this chapter, and the learnings are discussed over the next three chapters, Chapters 5, 6 and 7. In these, we include a description of potential solutions to these challenges that have been adopted in some business units of the sponsor company, combined with additional solutions derived from humanitarian and military supply chains, before consolidating our recommendations. The expectation is that the solutions presented in Chapters 5 through 7 can be used in the future for addressing the challenges presented in this chapter.

All the quotes presented in this chapter are taken from a series of individual interviews we conducted with employees of the sponsor company that are directly involved with project-driven supply chains.

### 4.1 Overview

> *"It is always one time, one shot and that's it."*

The nature of a project-driven supply chain is that it only exists during the timespan of the project. Complications arise because many times, the company's projects are located in remote places, and involve high uncertainty in supply and demand. Given the uniqueness of each project, many project-specific

challenges exist as well. For example, in some projects the materials are required in bulk, as illustrated by the following quote:

> *"We have different mines, different oilfields in different areas of the world and depending on what they are doing at the time they have to get materials for those sites, or they don't. Depending on those mines, oilfields nowadays, they are big numbers, you know. If they have to buy, it is going to be mostly a few hundred tons, not just a few tons. So it tends to be a little bit all or nothing".*

Through our interviews, we learned that many of the interviewees think of the different challenges they face regarding project-driven supply chains in terms of whether they occur during *planning* or *execution*.

***Challenges in the planning phase***

Planning is required for decision making regarding production capacity and delivery. Ideally, planning should take place as early as possible in a project. However, as we heard in the interviews, the biggest challenge facing the sponsor company during the planning phase is time pressure. Once a contract is awarded to supply materials for a project, there is significant time pressure from the customer, which translates into not enough time to carry out the planning.

This challenge is further compounded by the fact that, in the case of bulk orders for specific projects, more planning time is required because production capacity is seldom easily adjustable. Planning the production and temporary storage of a larger amount of product requires more time and effort on the part of the company.

Finally, in terms of delivery, unfamiliar regulations (e.g. concerning the movement of hazardous materials across political borders) and geographical barriers (e.g. below-freezing temperatures in Alaska or searing heat across deserts in Northern Africa) may require greater planning time and effort concerning transportation equipment and product packaging needs.

*Challenges in the execution phase*

In the execution phase, the key challenge is variability of conditions. A minimal change in conditions can have a large impact on the supply chain if it is not managed properly. This impact could potentially be magnified in the eyes of the customers, given that the project-driven supply chain is a one-time service and highly time-sensitive. Long-term corrective actions are not applicable in this case.

Variability could come from various sources, including difficulties with customs clearances, uncertainty or changes in regulations of the host country, uncertainty or inadequacy of local infrastructure, and even local climate (e.g. the ice roads of Alaska are only open during specific seasons of the year).

### 4.2 A categorization of key challenges

There are certain merits to thinking about the diverse challenges concerning project-driven supply chains in terms of *planning* or *execution*. However, we would like to propose a different approach. Through analysis of the data from the interviews, we identified eleven specific challenges facing the sponsor company concerning project-driven supply chains, which will be discussed below. Since most of these eleven challenges exist both during the planning and the execution phases, we would like to categorize them into three broad categories: (A) Business-specific, (B) Cross-border, and (C) Last-leg. A list of the eleven challenges, inside their respective categories, is as follows:

**(A) <u>Business-specific challenges:</u>**

- ***Challenge #1: Demand changeability***. The demand for project-driven supply chains in the sponsor company tends to be seasonal, cyclical and ever changing. Also, orders tend to come in bulk, which makes demand largely all-or-nothing
- ***Challenge #2: Customer-induced delays***. Customers are likely to request delaying the delivery of materials to the project site. This results in additional complexity and costs for the sponsor company.

- ***Challenge #3: Eroding margins.*** As new competitors enter the marketplace and specialty products become commodities, shrinking margins put pressure on the supply chain to be efficient.

**(B) <u>Cross-border challenges:</u>**

- ***Challenge #4: Regulatory differences.*** Transportation regulations and standards differ widely across countries, affecting the setup of the supply chain.
- ***Challenge #5: Customs-related bureaucracy.*** Import and customs clearance procedures create bureaucratic delays, which lengthen lead-time in the supply chain.
- ***Challenge #6: Dispersed supply-chain.*** When a supply chain spans across the globe, flows of product and information call for additional coordination efforts and enhanced decision-making processes.

**(C) <u>Last-leg challenges:</u>**

- ***Challenge #7: Remote destinations.*** Destinations are often located in remote areas characterized by geographical constraints and limited infrastructure, adding complexity to the delivery of products.
- ***Challenge #8: Extreme weather conditions.*** Extreme temperatures and prolonged exposure to the elements affect packaging and transportation strategies required to preserve material quality.
- ***Challenge #9: Equipment unavailability.*** Unavailability of specialized transportation equipment results in additional efforts to design adequate transportation strategies and tradeoffs in supply chain performance.
- ***Challenge #10: Lack of storage capabilities.*** Lack of suitable interim storage and warehousing facilities creates disruptions in the supply chain.

- ***Challenge #11: Cultural differences.*** Cultural differences can generate misunderstandings and miscommunication with the local population, which in extreme circumstances may create barriers to an effective execution of the project.

The summary above has outlined and briefly described the three *categories* and eleven *challenges* that we identified through interviews with the company. Below we elaborate in more detail on both the categories and the specific challenges.

### 4.3 Key challenges

#### *(A) Business-specific challenges*

Business-specific challenges are closely related to the nature of the chemical industry as experienced by our sponsor company. Factors such as demand, supply, customer behavior, geographical footprint, profitability and competition need be considered when looking at the company's supply chains from a 30,000-foot view. The competitive environment where our sponsor company operates is evolving, including a higher number of global competitors with increased product offerings and higher expectations from customers (who are also facing similar challenges within their own industry). We have identified three challenges specific to the chemical industry that fall under the "business-specific" category. They are described below.

#### *Challenge #1: Demand changeability*

Variability of demand is a huge issue in the sponsor company. As the two quotes below illustrate, customers change their order amounts, sometimes because of seasonality, sometimes because they changed their mind, resulting in production being readjusted.

> *"The [mining] season is May to October. Break it into two orders: one PO for the first half of the season, say 2,000 tons, and one PO the second half of the season for remaining material. [...] At the second half of the season, the customer says they do not need as much so 1,500 tons instead of 2,000. At that time, we have to readjust. We don't know [upfront] what the second PO will be for."*

*"We deal with the end-user, which is unique. There is a lot of variability. They change their mind, wait till [the] last minute to place stuff. Hence, the supply chain is just-in-time, no leeway."*

The chemical industry is also prone to cyclical effects, which are not always well understood.

*"It is a strange effect that we see. If I could think of a cyclical effect that runs every 10 years, perhaps 5-6 years, no one can really explain why. Across the industry we see that kind of swing from time to time."*

The demand variability and short time-span to readjust production can result in leftover products which have to be stored and maintained at extra cost to the sponsor company.

*"What didn't work so well was the product leftover at the end of the year [...]. The customer fluctuated a lot at the end. They wound up with alternative product, shutting down for a week, things that cannot be planned for. And I was stuck with material through the whole winter, which we did not want."*

From these quotes it is clear that high levels of uncertainty pervades the sponsor company's project-driven supply chains.

*"You get an idea of who we are dealing with, the type of atmosphere we are dealing with, all the variables involved: mainly outside influences, inventory control, lack of storage space, challenges of getting product delivered, human intervention or lack thereof, and the weather. It's a fire-drill all the time".*

Demand variability tops the list of issues highlighted by the interviewees. Each one of the interviewees has highlighted the project-driven supply chains as highly unpredictable. The effect compounds any seasonality or cyclicality that may be inherent within the business. Further pressure is placed on the supply side of the supply chain by the fact that demand often materializes in bulk orders of up to tens of thousands of tons.

***Challenge #2: Customer-induced delays***

Another variable that our interviewees highlighted was *the customer* as a source of disruption.

> *"For this project [...] we have had some difficulties because it was delayed several times by the customer. [...] All of the projects we supplied so far were delayed, often by more than six months. So the customer is also not sticking all the time to the original schedule fixed in the contract".*

> *"At some points, you could just wave your fingers in the air 'cause you are just guessing. [...] You can't blame the customer because they don't know they will shut down for a week."*

As described in the above quotes, planning of the supply needs to include risk measures to cater for variability of the delivery timeframe originally set by the customer.

The rationale behind this is that customers of the chemical industry are often large-scale contractors, whose business is also project-driven and hence susceptible to large variability and delays, which in turn will reflect on their suppliers.

The combination of the tight delivery windows (often required for chemical ingredients) and the project-driven nature of the customer's business make it likely that there will be additional costs and execution issues. This needs to be addressed within both the supply planning and contracting stage of the project.

***Challenge #3: Eroding margins***

Increased competition, together with lower market shares and, in some cases, competitive disadvantages (e.g. longer supply chains) constitute a new scenario the company is trying to adapt to. These are reflected in comments from several interviews, quoted below.

> *"I have worked at this site for 26 years now [...] and going back to the old days, it was very much specialty chemicals, which we'd be selling at specialty chemicals prices, and with very big margins. But, again, that's so changed now. There's a lot of competition out there, [...] so we now essentially sell commodity chemicals. It's always the same materials in a lot of cases, but they are now*

*commodity chemicals [...]. We're no longer able to command the same sort of prices that we used to, we're not making the same sort of margins that we used to."*

*"We have one main competitor with much larger market share. Our company is a small player and new entrant into the market. The competitor has the material produced in the U.S. [...]. Our competition has a much shorter and easier supply chain"*

*"I believe because the mine was pushed by the government to be self-sourced, or domestically sourced, that opened up more competition. The logistics would be just as difficult."*

In light of these comments, it becomes clear that no business unit is alike in the way it can influence the market, command prices and perform within the overall portfolio of products.

***(B) <u>Cross-border challenges</u>***

Global reach and country-specific regulations generate challenges for both planning and delivery of products, including communication, coordination, and understanding regulations and risks within each country. Delays due to cross-border challenges are often built into plans of the company. However, the nature of the competitive landscape that the sponsor company faces allows for little to no relaxation of the agreed-upon or required timelines for the delivery of its products. Three of the challenges that we identify fall under the "cross-border" category. These are described below.

***Challenge #4: Regulatory differences***

Having to operate in different countries means that there is a need to build knowledge about the different regulations in those countries, in order to be able to meet the challenges of planning and executing the operations of the project's supply chain. A specific issue regarding regulations that came up during the interviews is illustrated by the quote below:

*"One thing that was difficult for [serving customers in] the U.S. is the limited payload [that is allowed] for the U.S. road transport. If you are supplying such huge quantities, you are trying to*

*reach the optimum, maximum payload you can get in order to have the lowest related freight cost per ton. [...] (In the end) we had many more box containers [than we should have had] and this kind of stuff we also have to consider."*

High volume supply chains mean even a small difference in transportation costs can have a huge monetary value. On occasions, the difference may arise from regulations restricting usage of the optimal transport equipment in a specific country. When not anticipated and managed adequately, a slightly lower utilization of containers due to regulations on maximum payloads for on-carriage may affect the performance of the *whole* supply chain.

***Challenge #5: Customs-related bureaucracy***

One of the major issues brought up during the interviews was customs clearance and bureaucratic delays.

*"The problem really was the coordination between the sea carrier and the local customs agent selected by the customer [...] because, obviously, if you want to get the containers out of the port [in a foreign country] you have to nationalize them, you have to go to the customs authorities to declare them and all this kind of stuff, so that you can take them out of the port. It was sometimes quite difficult to make them work together. In some of the countries, bureaucracy is quite a challenge".*

Another quote, from a different respondent, reiterates this point:

*"Our biggest problems is clearing customs. It's a variable issue. We do not know whether there is a regulation such that all of a sudden everything shuts down."*

Import procedures can broadly differ across regions and often countries can have multiple layers of bureaucracy affecting the performance of the whole supply chain. Historically, these issues have been seen as falling outside the company's control. However, it is possible for a broad and comprehensive approach

to supply chain management to include adequate and pro-active processes for the management of customs clearance and import.

***Challenge #6: Dispersed supply-chain***

There are three types of coordination issues within the supply chain identified through our interviews. The first issue is the coordination of *data flows*:

> *"That was a whole new level of interruption as we had one SAP system talking to another SAP system and we had a lot of failures."*
>
> *"The biggest lesson learnt from these one-off projects [is that] all the stakeholders [should be] upfront giving you all the information. You may not fail, but you will be very inefficient if you don't have all the information."*

The second issue is the coordination of *decision-making* within the supply chain process:

> *"We have our dispatchers, people who control our fleet, sit next to customer-service people. They use each other as sounding boards. It's immediate information, because there are no walls. They are not separated by 60 feet of concrete. [Instead they are] 6 feet apart. They work together."*
>
> *"It is not always the case [that] there is very good communication between the various departments. You have an operations department at the mine site, but the procurement department was in Australia. Yes I might have communication electronically, but it is not the case where I am sitting in the next cubicle, the next office, and let's have a committee meeting or taskforce once a week or once a month [...] It can end up, in effect, create silos where the objectives of different departments may somewhat be directly or opposite or bumping up against other departments."*

The third issue is the coordination of *physical flows* of products:

> *"Having a long supply chain is very tough to deal with. Things like mother nature, weather, customs, steamship lines. Takes a lot of control. Losing control creates uncertainty. Customers [are] scared to sign big contracts with [high levels of] uncertainty."*

Being in separate countries or areas makes it imperative for up-to-date information to flow as quickly as possible to all units involved in the supply chain, particularly for project-driven supply chains, which usually have to be set up within a short duration.

Coordination of decision-making within the supply chain, after being supplied with the relevant information, is equally crucial to the effectiveness of the supply chain. With global supply chains stretching across countries and even continents, and physical proximity of personnel often impossible, this affects information flow and consequently decision making across the supply chain as a whole.

The physical flow of materials is equally impacted. A longer supply chain means more lead-time for transportation of materials and increased coordination requirements with customers and logistics providers.

***(C) Last-leg challenges***

The last section of each supply chain presents planning and execution challenges of its own. Being in a foreign country of any kind across the globe presents challenges around infrastructure and equipment availability, preserving the quality of transported materials, storing them over a certain period of time and dealing with a multitude of different cultures.

We have identified five specific issues that are related to the last-leg section of the company's project-driven supply chains. These are described below.

***Challenge #7: Remote destinations***

The particular geography or terrain of the theater of operations can create many unique challenges. One interview described how materials had to traverse tunnels to get to a project site.

*"This was a project where all chemical products and equipment had to be broken down to a certain size to fit through the tunnel. The mine site was at 14,500 feet above sea level and the mill site was at about 11,000 feet and there was one very small road and a number of tunnels."*

Limitations in infrastructure due to the unique geography, such as availability of roads through mountains or during certain periods of extreme weather, was also mentioned. Consider the following quotes from separate interviews:

*"[There was] no wiggle room once the ice roads softened up, there [was] no way to get that kind of volume up there. Challenging business."*

*"We finally delivered up to 20 trucks per day from our interim storage in [a port in the African continent] to the [customer's] production site, which was around 400 km crossing the [African] mountains. The roads across this mountain chains are not comparable to, let's say, roads around the U.S. or highways in Europe and then it's quite difficult with 20 trucks per day to cross these mountains to be in time for the melting process."*

*"What was not easy that we had to drive through the mountains of [Africa] and there was only one road and the road was open only for 5 hours in every direction so we only had a slot of 5 hours on the road."*

As most of the project-driven supply chains are delivering to remote areas with geographical constraints like mountains, deserts and ice, and with bad or limited infrastructure, the supply chain challenges of planning and implementing the delivery of products across such terrain are complex. This is especially so when coupled with demand uncertainty and the need to deliver bulk shipments.

***Challenge #8: Extreme weather conditions***

In summary, there are two main concerns reflected by the practitioners in terms of extreme weather conditions the shipped materials have to endure. Firstly, a lack of proper packaging may cause the materials' performance to deteriorate due to exposure to the elements.

> *"The weather, mother nature, is truly your best friend or your worse enemy. Nobody can predict that."*

> *"[Weather] has a massive role, effect. Our product line is water-based products for the most part. In adverse conditions like temperatures below 20 degrees, you've got to figure out how to transport products without freezing. So, you've got a different mode of transportation, additional costs, concerns, timeframes because you cannot ship over weekends. All that plays into it. Weather does affect the business, overall, we see a 25-30% reduction in business in the winter months in North America. That is because 2/3 of the service area is in the winter zone."*

> *"There is an old story to give the bias on the [business unit] side here, but as I say, there is no bagged cement, only bad cement. Therefore, the cost was very steep because it was packaged, obviously. And also, I think you are aware of the environmental conditions in [a country in Southeast Asia], it is a very humid place. The level of performance that you'd be getting from some of these materials, which I think we probably handled very well, whether it was packaging or how we equipped the products we were selling through at the time, maybe it is not as much up-to-scratch as it is being supplied from [the Southeast Asian country]."*

Secondly, temperatures above or below a certain level may cause changes to the chemical properties of the materials and affect its performance.

> *"You have to deal with the temperature for the material for example, how long you can store the big bags in the container if it's too hot in the container"*

*"Certainly environmental issues, you may have products that cannot ship under extreme heat or cold."*

***Challenge #9: Equipment unavailability***

Transportation equipment availability differs from country to country. Not having the relevant equipment meant that available equipment would have to be adapted for that purpose and that trade-offs had to be accepted. Specifically, one of the interviewees mentioned the lack of availability of Tautliners (i.e. curtain sider trucks or trailers) in the U.S which resulted in having to use and adapt to a different type of trucks for transport purposes.

*"We had a project in [Southern Europe], so we were used to using the Tautliners. This was not a problem of having sufficient equipment of this type of trucks and then it was the first time we figured out this kind of equipment was not available in all parts of the world as we'd thought before. And then we had to switch and reconsider also with regards to quality aspects, transport security and so and then the type of transport equipment available in the U.S., which was all flatbed."*

***Challenge #10: Lack of storage capabilities.***

The inability to find suitable interim storage facilities creates a disruption in the supply chain particularly in the situation where the products have certain hazardous components or chemical properties that could be altered easily if exposed to temperature or the elements. Several interviewees raised this as a concern.

*"To complicate matters further, there was no storage space in [an island in the Pacific] for us to set up tanks in order to put our material in after it got delivered."*

*"We did not find a warehouse for 27,000 tons of dangerous goods in [a country in the Middle East]. They thought about building a warehouse but to get permission from the [country's] state, it takes, they mentioned, 2 years."*

This is further complicated by the bulk shipment orders commonly seen in sponsor company's project-driven supply chains.

***Challenge #11: Cultural differences***

Understanding local cultures and customs is not easy, as explained by some of our interviewees in the quotes below.

> *"We had to deal with other people, we had to deal with other cultures, so at the beginning it was not so easy, but I think at the end of the day we did a good job."*

> *"It makes it even more complicated because looking at the solar belt countries, like Chile, Texas, California, going to China, Mongolia, going to Saudi Arabia, these are very special countries with very special cultural habits and you have to consider all these kind of things."*

These can sometimes lead to misunderstandings and miscommunications with local service providers or local employees, which could delay the implementation of the planned supply chains. Indigenous people with discontent against foreign multinationals and their projects could even be a danger or a disruptive force for the supply chain. This is specifically pointed out by one of the interviewees as quoted below.

> *"It was difficult to be able to get fully involved, from our company's perspective, due to the requirements and or the sometimes simply cultural issues."*

### 4.4 Similarities with humanitarian and military supply chains

As briefly argued in Chapter 2 (Literature Review), while there is increased cooperation among military, humanitarian and commercial supply chains, such cooperation seems to be limited to joint operations in disaster relief, and *does not* include cross-learnings among these three fields. We believe that learnings from humanitarian and military supply chains could be beneficial for commercial supply chains in particular project driven supply chains. These cross-learnings could be particularly valuable because commercial project-driven supply chains are relatively less well researched than humanitarian or military supply chains.

There are three main similarities between humanitarian, military and commercial project-driven supply chains.

(a) *Temporary nature* – All military operations are designed with an end-goal in mind. They often include an eventual move into the reconstruction and rebuilding of the country. This is similar to events-driven humanitarian operations where humanitarian organizations would plan to leave after their mission is complete. This also applies to commercial project-driven supply chains, which were set-up for the period of supplying a particular project. We expect many of the objectives and issues faced are thus similar. Specifically, Ursa, an expert in operational research, is of the opinion that "humanitarian supply chains are one off supply chains like the project-driven supply chains.... Once it serves the region, it is completely removed".

(b) *High uncertainty* – Humanitarian supply chains are often defined as events-driven, as their main purpose is to address an unexpected, undesirable event such as a natural catastrophe or the dramatic escalation of a conflict (Christopher & Tatham, 2011). Military supply chains are characterized by high unpredictability. Even the definition of a military supply chain varies broadly in accordance with the breadth and background of the mission in question. This matches the uncertainty prevalent in project-driven supply chains.

(c) *Remoteness of locale and uncertainty of infrastructure* – Brian, who as a former helicopter pilot has "mostly been a customer of military supply chain", states that a military supply chain is project-driven "as it is required to bring a lot of equipment where, essentially, nothing is there". In fact, all our military interviewees unanimously recognize that a military supply chain is project-driven. A good example would be the U.S. campaign in Afghanistan, in which the mountainous territory and lack of infrastructure forced the Army to bring in building material for bridges and bases. In humanitarian logistics, the 'last mile' has always been a major area of concern because disaster often happen in remote locations and in the best of times, the country's infrastructure can be unreliable and during disaster, it could be damaged or destroyed. (Fenton, Goodhand & Vince,

2014). David Kaatrud, former Chief of Logistics for the United Nation's Joint Logistics Center (UNJLC), has asserted the following regarding humanitarian supply chains: *"Our operational settings are typically very different and difficult. To get supplies to the most remote area, we may have to resort to a range of imaginative and unconventional delivery systems, from air-dropping to using elephants for transport."*

Given the unfamiliarity and short time period often available for set-up of project-driven supply chains, the issue of remote location and unknown infrastructure applies similarly to project-driven supply chains as well.

**4.5 The value of cross-learnings**

Given these similarities listed above, it is our opinion that cross-learnings from humanitarian and military supply chains would be of value to the study of project-driven supply chain challenges.

Specifically, for the military supply chains, our interviews have given us the understanding that the spectrum of military supply chains ranges beyond sustainment of combat. Military supply chains also include a variety of *projects* presenting similar constraints to the ones faced by the company. These range from the efficient setup of a one-off supply of materials for the construction of camps, the last-mile delivery of hazardous materials, such as fuel and ammunition, to a set of remote locations, and the import of specialized, highly-valuable vehicles in distant foreign countries and locales.

In humanitarian supply chains, there would be value for project-driven supply chain planners and implementers learning from practitioners who are skilled at implementing highly complex supply chains under high levels of uncertainty with limited resources and infrastructure. This point of view is supported by Tomasini and Wassenhove (2009), as well as several of the humanitarian experts we interviewed.

With the above in mind, in the next three chapters, we report a series of possible solutions to the challenges of project-driven supply chains in the chemical industry for each of the three categories: (i) Business-specific, (ii) Cross-border, and (iii) Last-leg. These solutions will not only consider those practiced in the

sponsor company and in commercial settings but also in humanitarian and military settings, based on the degree of similarity among these areas, as discussed above.

## 5. Business-specific solutions

In the previous chapter, we described three business-specific challenges faced by project-drive supply chains in our sponsor companies: (1) demand changeability, (2) customer-induced delays, and (3) eroding margins. In this chapter, we propose a series of eight possible solutions to these three business-specific challenges. These proposed solutions are derived from best practices identified inside the sponsor company, and elsewhere in commercial, humanitarian and military supply chains.

### 5.1 Brief overview of solutions

The eight possible solutions reported in this chapter include the following:

**Solutions to challenge #1: Demand changeability**

***Solution #1: Pre-planning processes.*** Installation of a robust sales & operation planning (S&OP) processes which would include sensing, shaping and quantifying demand, upfront supply chain involvement, and timely executive decisions on capacity in anticipation of predicted future demand.

***Solution #2: Flexible and upfront contracting.*** Use of flexible contracting, including pre-approved supplier agreements for additional demand, and flexible transportation contracts with previously vetted carriers, and putting in place a quick funding process, to speed up project implementation.

***Solution #3: Vendor managed inventory.*** Managing schedules of the client's product replenishment, including holding inventory at the customer's physical location, to effectively respond to sudden demand variations.

***Solution #4: Modularity.*** Ensuring equipment is designed for ease of redeployment, conversion or reuse. This includes transportation equipment such as containers, material bags, and any supporting processing equipment.

***Solution #5: Systems integration.*** Integrating order processing, export, inventory management, invoicing and payment systems with customer and / or carrier systems in order to guarantee high visibility and faster implementation of changes along the supply chain.

**Solutions to challenge #2: Customer-induced delays**

***Solution #6: Provisions within the contract on material delay.*** The contract could allow the customer to request delays in the delivery of materials, as long as these delays do not exceed a predetermined grace period. Beyond this period, further delays would incur additional costs to the customer. Contract negotiation is required to ensure such provisions do not affect evaluation of cost-effectiveness of the submitted bid.

***Solution #7: Risk-sharing mechanisms.*** Inclusion in the contract of a pre-defined mechanism, at an agreed price, to assess and respond to unforeseen circumstances, in order to ensure a timely delivery. The mechanism requires close collaboration and sharing of data between customer and supplier.

**Solutions to challenge #3: Eroding margins**

***Solution #8: Continuous reorganization.*** Continuous evaluation of desired value proposition to the customer, and subsequent rearrangement of roles and responsibilities within the company and the supply chain system in order to be aligned with the agreed-upon strategy.

While not universally applicable, these proposed solutions are possibilities worth considering when setting up a project-driven supply chain in the chemical industry.

## 5.2 Detailed discussion of the proposed solutions

The identified possible solutions to each highlighted business-specific project-driven supply chain challenge are reported in the following.

**Solutions to challenge #1: Demand changeability**

The following solutions help address demand variability by means of robust planning processes and a flexible, integrated supply chain design.

***Solution #1: Pre-planning processes***

Given the uncertainty of disasters, humanitarian organizations generally engage in emergency preparedness to various extents and attempt to plan in advance. Often such planning is done in phases (Wakolbinger & Toyasaki 2014). Ursa, who has studied disasters and emergency response across Mexico, states that phases of a disaster would typically cover: (i) preparation, (ii) response, (iii) recovery, and (iv) mitigation. Neruda and Mistral highlight that requirements may vary across and even within different phases. For example, early in the response phase, water, food and medical supplies are needed, while in a later period, shelters would have to be procured. These pre-planning actions are typically reflected in documents such as *guidelines* or *templates*, and – for learning purposes – shared in the form of *best practices*.

In a commercial environment, as highlighted by Antiguo, a consultant with over 30 years of supply chain experience, pre-planning can be performed as a preparatory activity in the form of a robust sales & operation planning (S&OP) process.

Antiguo states a robust S&OP process starts with building a forecast based on sensing the demand close to the customer. This means delegating company personnel to closely communicate with key and potential customers both at headquarters, and at local /site office level in order to get the full picture of the upcoming demand. Demand can then be shaped (i.e. rearranged, brought forward and/or pushed back), in order to ensure minimal disruption to the company's operations. Additionally, the process must involve supply chain

personnel early on, in order to enhance the ability of the company to deliver the potential forecasted orders. At several points in time, the process includes timely executive decisions on whether to adjust (invest or divest) the available capacity in order to anticipate the predicted future shape of demand.

***Solution #2: Flexible and upfront contracting***

In order to enhance their response to changes in demand, some business units within the sponsor company have a list of pre-selected and vetted carriers, which is kept on an electronic database. Carrier information such as lead-time, cost and variability can be accessed in order to ensure optimal selection when the need to use them arises. Orders are submitted electronically in order to minimize processing time.

In the military, flexible transportation contracts are often set-up to satisfy demand exceeding the system's design capacity, as reported by Tom, who has several years of experience in procurement and transportation contracts. Whereas – in the case of the U.S. Armed Forces – global transportation contracts are handled centrally by U.S. TransCom (Transportation Command), a local footprint is often created by U.S. and U.K. contractors, who would establish local transportation companies and employ local people. This strategy allows the contractors access to lucrative opportunities in countries where resources are not originally present, creating additional capacity and flexibility in the system.

Furthermore, two common contracting approaches towards developing an effective response to uncertainty are identified by other military interviewees:

- *Quick-funding* involves, as Christian, the high-level planning expert, describes, having contingency funds for overseas operation. The funds are on top of the defense budget and hence additional to the day-to-day budget for operations & training. Contingency funds are obtained by pleading to Congress, first obtained in large portions and then subdivided into individual allocations depending on the overall amount received. Allocations may include logistics, operations and local procurement. Currently, limitations on usage of contingency funds have

been introduced by specific personnel in the budgeting department, so that the funds will not run out prior to re-granting.

- *Upfront Contracting*, as mentioned by Craig, who has experienced several issues with local contracting, involves creating a command of trained personnel to go out and assess the country's capabilities prior to the operation. The deliverable of the assessment will be a list of capabilities, vetted contractors and planning information. In this way, the assessment aims at reducing the stress related with the process of approving the overall plan for contracting and procurement, which can easily take 180 days. A side benefit also involves preventing an immediate surge in price during the invasion due to the constrained local capacity – on occasions, personnel has been, unknowingly, bidding against their colleagues, desperate to lock capacity and driving up prices several-fold.

In addition, since the core of the military logistics processes arguably happens in the field, in which disturbances are routine and any interruption can bear extremely high consequences, the military employs several agile strategies for emergency replenishment, in order to prevent disruption in its supply chains. In this case, methods are designed to be able to respond to any disturbance by being as agile and responsive as possible.

Examples of agile replenishment are reported by Craig and Ethan, both of whom have significant field experience. A defined path of expediting actions may be common in this regard. As an extreme example of expediting action, Craig mentions *bypassing throughput*. By allowing the supplies to follow a more direct route - sometimes with the support of Air Force or Marine Corps - it is possible to save costs on the five mandatory steps of replenishment, namely: (i) movement, (ii) storage, (iii) inventory record, (iv) maintenance, and (v) collection. Although this practice will significantly increase the overall risk within the supply chain, it is sometimes necessary in order to prevent a costly interruption.

Possibly one of the most extreme examples, Ethan, a former junior officer at the Navy, describes the extreme replenishment strategies used in submarine logistics:

- *In-port replenishment* involves arranging personnel in a human line to load materials onto the submarine. In safe ports, qualified supplier personnel may be allowed to get on board to load the materials directly. In-port replenishment coincides with "liberty time" for staff in order not to add any down-time to the submarine operation.
- *BSP (Brief stop for personnel)* involves the submarine pulling into waters protected from the open ocean to meet a supplier's tugboat loaded with supplies. A brow (an inclined plane of planks) deployed from the tugboat allows getting the materials into the submarine hatch. BSP is significantly faster than in-port replenishment, but also involves a much higher risk and an expensive, capable supplier.
- *One-off supplies* can be arranged for repair in accordance with the position of the vessel (in port or open water, domestic or overseas) and the nature of the required repair. Immediate redirection to port may be arranged with the part being delivered *in loco* by air (sometimes someone might have to hand-carry it on a plane). Replenishment of any supplies can be conducted on the spot via company credit card.

The listed examples confirm military supply chains largely rely on pre-defined, flexible strategies to allow agile or emergency replenishment.

The issue of whether a commercial organization should adopt a central or local transportation contracting strategy is addressed by Antiguo, who argues he has seen both work. However, in the case of military-style, local contracting, Antiguo advocates for the engagement of a local consultancy to help the company navigate local capabilities.

Humanitarian organizations also rely on a pre-approval process for contracts in case of emergency, as noted by Mariano. Procurement contracts are placed ahead of time for organizations like the Red Cross with fixed prices for items such as tents and the supplier would hold on a certain amount of the inventory. In the event of an emergency, the supply contract comes into force, and this expedites both the procurement process within Red Cross as well as the actual delivery lead time of the item. Mariano also shared that the Red

Cross makes efforts to develop local footprints and do local contracting. This is similar to some of the military practices highlighted by Tom. Research by Lu, Goh and De Souza (2013) also shows that supplier agreements of various natures are prevalent in other humanitarian organizations like Indonesian NGOs in order to provide fast response in the aftermath of an emergency.

Antiguo argues that such a process is feasible for a commercial organization, by setting a series of pre-contracts including mutual agreement in terms of additional capacity that can be provided, lead-time and costs.

Flexible contracting is a complex subject, but reported examples from all investigated fields strongly encourage its adoption in order for the company to effectively manage responsiveness.

***Solution #3: Vendor managed inventory***

In order to tackle demand variability, some company units run a kind of vendor-managed inventory (VMI), where a customer sales representative is on location with the customer for the entire project (or season) and communicate back to the HQ as when to release additional POs and arrange replenishment.

VMI is also applied by several humanitarian organizations. As reported by Rory, the Federal Emergency Management Agency (FEMA) practices VMI with their suppliers, where FEMA pays upfront and requests suppliers to keep the supplies and deliver only when required.

As reported by Antiguo, VMI initiatives fit within the recent perspective of inventory visibility being one of the hottest topics in supply chain consultancy at the moment. A customer being able to tell where the inventory is takes a lot of pressure off the supply chain, and having some inventory sitting next to the customer improves the ability to respond quickly to any sudden variations in demand.

***Solution #4: Modularity***

Some of the projects of the sponsor company make use of dedicated equipment that is located at the site of the project. The useful life of this equipment, however, is usually much longer than the duration of any

individual project. Therefore, it is desirable for equipment like this to be reusable in other, successive projects. Therefore, wherever possible, the company designs such equipment keeping in mind its ease of redeployment, conversion or reuse. Equipment design also needs to take into account the ease of transporting it through difficult terrain, a task that usually requires breaking the equipment down into compact units or modules. One example, shared through the interviews, is a production plant, which can be assembled by connecting a series of 20-foot containers.

This strategy resonates with military and humanitarian assistance equipment and facilities, which are designed for quick transportation, assembly, dismantling and redeployment. Any redeployment of facilities creates the requirement for a reverse supply chain, a topic of significant interest for the sponsor company.

In the military context, reverse supply chain indicates sending back previously shipped equipment after ceasing of operations. As Brian highlights, based on his experience of occupation and retreat, it is required for the military to break down and ship back "all items that are sensitive in nature". The principle clashes with economic viability, as transportation costs do matter on reverse supply chain. A US$30,000, war-damaged, military vehicle may cost up to US$50,000 to be transported back. Accordingly, certain items would be left behind, making reverse supply chain a possibility, but not a strict requirement. This strategy of course ignores any environmental impact of the leftover equipment.

***Solution #5: Systems integration***

Some divisions in the sponsor company have focused on speeding up information flows all the way up within the supply chain, enhancing responsiveness. In this industry, a significant competitive advantage can be achieved by integrating customers and suppliers within the company's network. Within the chemical industry, it is common to have echelons of internal customers, with which the company is striving to achieve even more end-to-end integration. Integration may include order processing, generation of export documentation, invoicing and payment.

**Solutions to challenge #2: Customer-induced delays**

The following solutions help address changes demanded by the customer by building effective response mechanisms in the supply contract.

***Solution #6: Provisions within the contract***

Some of the company divisions have addressed the issue of customer-induced delays by including a provision for a two-month logistics delay within the contract. The provision is reflected into updated contract terms, specifying that the company agrees to cover up to a certain period of customer-induced delays (e.g. two months of additional product storage) and, from then onwards, all related logistics cost will have to be covered by the customer. On the flip-side, though, such a strategy may increase the overall total cost of the supply and affect the ability to get the contract if bidding is based on exclusively on pricing.

***Solution #7: Risk sharing***

Slowly being adopted within several industries, performance-based risk-sharing contracts are seen by Antiguo as a strategy to minimize costs for the whole supply chain. Such contracts would include mechanisms incentivizing both supplier and customer to work together towards achieving a timely or early completion of the supply. Essentially, all risks are listed separately, with mechanisms defining their impact on the final price of the contract. This ensures that little or no contingency is included in the base contract, hence minimizing its total cost. In order for such a strategy to be successfully implemented, though, the existing relationship between customer and supplier needs to be transparent and based upon open cooperation.

**Solutions to challenge #3: Eroding margins**

The following solution helps address shifts in the competitive landscape that may potentially hinder the effectiveness of the company's value proposition to the customer.

***Solution #8: Continuous reorganization***

Dominant patterns in demand, consolidation of volumes due to industry trends, and integration of newly acquired companies lead the company to pursue continuous restructuring and reorganization, for the purpose of being more cost-efficient and more effectively coordinated.

Part of this reorganization is the segmentation of products into different categories based on patterns in demand, with the idea of creating more effective supply chains. The company is undertaking a demand segmentation project to establish which products undergo the highest levels of variabilities and arrange the management of inventory accordingly.

Segmentation also leads to differentiation in the whole value proposition to the customer. For example, following the shrinking of chemical prices due to increased global supply, some divisions are moving towards leaner processes, cutting production costs in order to generate margins. The process often involves consolidation of volumes, as described in the overview section to this chapter, and, consequently, a more standardized (and less personalized) service level across customers.

Other divisions have approached the challenge with the opposite strategy. Being considered as a "one-stop shop", i.e. a supplier with larger product range and higher service capabilities, has allowed these divisions to maintain their prices at a higher level than the competitors', without losing business. Each solution entails different levels of investment and risk.

Business consultants such as Antiguo advocate reorganization, no matter the detailed actions taken, in order to build a solid reputation with key customers. A solid, well-established reputation of delivering in line with – or above – expectations, will then allow the company to compete based on highest proposed value, i.e. most compelling bid in terms of a combination of price, quality, service level and reliability, rather than merely on lowest cost. Customers, especially in the construction industry, still tend to be biased towards selecting the bid with the lowest sticker price, which can prove hazardous during the delivery of the project if additional aspects such as material quality and reliability are not addressed. Only a solid reputation allows

suppliers to drive customers towards acknowledging the actual added value embedded in each proposal as part of their bid evaluation processes, and hence making the overall best choice for the most effective and efficient delivery of the project.

In conclusion, Antiguo highlights that meaningful reorganization following changes in the market and competitive landscape may also entail the secondary benefit of preventing the build-up of a stagnant, habit-driven corporate culture by creating an ongoing drive for change and continuous improvement.

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In the next two chapters, we report a series of possible solutions to the challenges of project-driven supply chains in the chemical industry for the remaining two categories, (ii) Cross-border, and (iii) Last-leg.

## 6. Cross-border solutions

In this chapter, we report a series of possible solutions to challenges of project-driven supply chains regarding import, foreign country regulations and international coordination. In order to do so, we summarize best practices identified from within the company, and humanitarian and military supply chain experts into a range of five possible solutions, categorized following the challenge they address.

### 6.1 Brief overview of solutions

The five possible solutions reported in this chapter include:

**Solutions to Challenges #4: Regulatory differences & #5: Customs-related bureaucracy**

***Solution #9: Centralized knowledge base, institutional knowledge building and documentation.*** Development and maintenance of a centralized knowledge base, ensuring adequate collection of information, timely update and effective transfer of lessons learned.

**Solutions to Challenge #6: Dispersed supply-chain**

***Solution #10: Specific supply chain roles.*** Development of clearly defined, project-specific roles and responsibilities, coupled with a structured decision making process following key steps, would provide adequate support for effective coordination across the global supply chain. Care is needed to provide flexibility to allow for changes required in the 'last-mile'.

***Solution #11: Knowledge transfer, institutional expertise retention and documentation.*** Development of documentation processes ensuring transfer of expertise concerning the properties of the product (including its suitable means of transportation), as well as the setup processes of project-driven supply chains; and retention and training of experts in which institutional knowledge resides.

***Solution #12: Guidelines and templates.*** Development and update, as required, guidelines and templates to support coordination across borders, accelerate learning processes and knowledge transfer, as well as provide continuity in terms of knowledge within the organization.

***Solution #13: Physical proximity.*** Design processes for close collaboration of key personnel, including physical proximity of related teams, cross-unit simulation exercises and relationship building.

***Solution #14: Distribution frameworks.*** Design and implement transparent phased processes for progress tracking, reporting and communication within the supply chain.

As before, the proposed solutions do not claim to be universal, but rather key possibilities worth considering when setting up a project-driven supply chain, as further explained below.

### 6.2 Detailed discussion of proposed solutions

The identified possible solutions to each highlighted cross-border project-driven supply chain challenge are reported in the following.

**Solutions to Challenges #4: Regulatory differences & #5: Customs-related bureaucracy**

The following solution helps address the challenge of building and keeping institutional knowledge up to date regarding different import regulations and import rules worldwide.

***Solution #9: Centralized knowledge base, institutional knowledge building and documentation***

One way to deal with import issues is centralizing knowledge and documentation. The company has a global operations team (located within the HQ), which deals with documentation and invoices minimizing the probability of delays caused by inadequate or incomplete documentation.

In addition to the centralized knowledge base, sharing of previous knowledge among peer suppliers who have delivered similar supplies in the past may prevent overlooking specific regulatory issues within certain countries. Within the specialty chemical business, other suppliers may be awarded contracts to deliver products that complement the ones in the company's offering, which prevents any confidentiality issue related to direct competition.

The above process has been tested by one of the divisions in the sponsor company. On a specific project, the division has shared some of its knowledge about regulations in a specific country to facilitate a supplier to deliver its product and ensure a timely processing of the two complementary products by the customer.

Within the military, interviewees believe the use of *templates* may support the setup and accomplishment of repeatable tasks. According to Brandon, a former U.S. Marine, templates are developed informally within the U.S. Marine Corps logistics by reusing and tweaking previous plans. A similar situation is reported by Ethan, who claims templates are developed over time in U.S. Navy submarines to speed up in-port replenishment.

Furthermore, consolidated templates can help support transition within a high-turnover environment, such as a project-driven environment. In Africa, the U.S. Army is developing an Adaptive Logistics Network Initiative (ALN). The ALN is a central database which documents trusted African businesses and their capabilities with the intent of linking them with customers that include U.S. military, non-government organizations and multinational companies. It is a repository of knowledge about suppliers that can be accessed online to avoid redundancy and provide assistance to incoming units (because of the high turnover rate of personnel) to identify promising options. It saves time and effort wasted searching anew for vendors (King, Moss, & Pittman, 2014).

According to Heath, learning the specific country characteristics is key to a timely setup of the supply chain within the U.S. Army Life Cycle Management Command. Heath confirms the availability of logistics "lessons learned" on a web portal, although with access separated by country of destination.

The importance of knowledge transfer and accumulation also applies to many other aspects of the supply chain and will be discussed under the next section in more detail.

**Solutions to Challenge #6: Dispersed supply-chain**

***Solution #10: Specific supply chain roles***

There are ongoing projects within the sponsor company to implement processes aimed at increasing coordination among business units. The current existing global operations group and the transportation solutions department are actively involved. The ongoing projects include installation of specific supply chain roles, such as demand and supply network planners.

Within the humanitarian sector, a lot of emphasis is given to clear allocation of roles and responsibilities for coordination purposes. In a disaster zone, there are often multiple organizations involved in the relief efforts. Ursa's account of organizations involved in the 2008 Mexico flood includes the Mexican Army, Non-Governmental Organizations (NGOs) such as the Red Cross, private companies, federal government ministries, local municipalities, and local society (social capital). Without a clear role and responsibility allocation, organizations would duplicate work and increase confusion and bottlenecks in the supply chain. This would result in gaps in aid delivery to people in need.

The U.S. Incident Command System (ICS) was highlighted by Mariano as a good case example. All U.S. government personnel and agencies are trained in ICS for domestic incident management. Thus, during a disaster, agencies and personnel could slot themselves into pre-allocated roles, minimizing inefficiencies.

Finally, special mention must be made of the coordination between local and federal agencies, and their allocation of roles and responsibilities. In an emergency situation, concerns may arise from the inability of local and federal personnel to be in close proximity, as well as – oftentimes – from federal-local political tensions. This may lead to breakdown and delays in relief operations. A clear example would be an incident shared by Rory, in which – in order to gain access to a disaster zone to deliver relief supplies – a convoy of 240 ambulances were instructed to blare their sirens (thus giving the impression that they were there on medical business). This allowed them to be waved through without delay into an otherwise off-limits area.

The idea to use the ambulances came after a 2-day delay that resulted from an inability to contact local authorities to obtain access approval.

The military, instead, is well-known for its structured decision-making process, known as the Military Decision Making Process (MDMP). Designed to allow clear accountability for decision making, the MDMP has all decisions follow the same key steps, including: (i) Receive Mission, (ii) Mission Analysis, (iii) Course of Action (COA) Development, (iv) COA Analysis, (v) COA Comparison, (vi) COA Approval, and (vii) Orders Production (Henderson, 2008, p. 96). A high level of autonomy is always reserved for command on the ground as ground situation changes.

Clarity on the decision making process flows into clearer understanding of own responsibilities. As Brandon states, "it was clear that [as logistics officer within the Marine Corps] I could take orders from three people in the organization only". Ethan adds that, as a junior officer, the Supply Officer on a submarine would have budgets tied to his responsibility for food and small supplies, but no limits on maintenance. In case of an emergency, it would be up to the Commanding Officer to define the bottom line of all related purchases, including mode and delivery priority. In the military, structure is key to facilitate decision-making under pressure, in particular to make clear the person ultimately responsible for making the decision.

A combination of clearly defined, project-specific roles and responsibilities, and a structured decision making process may provide the company with the right level support towards achieving a coordinated project-driven supply chain.

***Solution #11: Knowledge Transfer, Institutional Expertise Retention and Documentation***

Within the sponsor company, there is a general acknowledgment that knowledge is imperative to reduce costs and save time. Two types of knowledge were identified as imperative to the reduction of costs and time: (a) familiarity with both the properties of the product (including its suitable means of transportation), and (b) understanding of the set-up processes of project-driven supply chains.

The key challenge identified is that much of the knowledge required, comes from individuals and their years of experience, rather than any form of formal training or institutionalized processes within the company. There is thus a need to look into processes reorganization, and retention of experts to keep crucial knowledge within the company.

Humanitarian supply chain theory highlights that knowledge is created in three levels: (i) field, (ii) supply chain and (iii) theater levels. The field operations level is the most people-intensive and, in the case of project-driven supply chains, it is analogous to the last leg phase (which will be discussed in the next section in more detail). Humanitarians in the field are considered the main source of knowledge due to their proximity to the conditions and needs of beneficiaries. Here the knowledge resides in *people*. The second level is the supply chain level, where knowledge resides in the *processes*. The third level is the theater level, where knowledge resides in the *context*. In terms of project-driven supply chains, the knowledge transfer requirements for the theater level have been discussed in the previous section on centralized knowledge base above (Tomasini & Van Wassenhove, 2009).

Some humanitarian organizations, such as the Federal Emergency Management Agency (FEMA), address the field operations level by functioning based on a pool of volunteers, as reported by Rory. While this alleviates the manpower and supply chain expertise shortage, there are limitations as volunteers are not assured manpower and turnover is very high.

As suggested by one of our interviewees, volunteer schemes between private companies and humanitarian organizations, to allow short-period volunteering from logisticians working in the private sector, should be considered. While currently, private sector logisticians are free to do so in their leisure, a more structured scheme as such, would enhance not only the humanitarian organizations' capabilities but eventually those of the private companies as well, building up more institutional knowledge and experts available in the field. Work has already begun to create a new breed of "hybrid logisticians".

The Humanitarian Logistics Association (HLA), registered in 2009 as the first professional logistics association within the aid sector, has 2000 members based in 106 countries. The HLA supports training initiatives, best practice exchange etc., and has the backing of the UK's Chartered Institute of Logistics and Transport, and partnering with the RedR UK training agency to provide technical advice and support (Fenton et al. 2014).

Additionally, consolidation of lessons learned is a subject often lacking priority compared to operations, in particular in one-off activities. Compare this, for example, with the way lessons learned are collected in the U.S. Marine Corps: Brandon reports a systematic process of collecting successful actions taken in battle, validating them and making them available for training by the training center.

The lessons learned consolidation process can be cumbersome due to the geographic distance covered, the sensitivity of information and constant overwhelming of communication channels. Whereas most personnel would keep a journal of useful observations, speed of transfer can be an issue when the average tenure for a position is around two-three years. It is often up to the individual, as Ethan highlights, to take the extra initiative to get the information to the right facility.

Brandon advocates for a more agile lessons learned collection process allowing for sessions to gather information and then quickly disseminate it to staff, given the high job rotation level typical of the U.S. Marine Corps. The higher up the ranks the personnel involved, the more access they have to resources, positively impacting the process of collecting lessons. Ethan adds a potential career path leading from in-the-field to office position, which may facilitate transfer and consolidation of lessons learned. Rory reports that FEMA uses a database which originates from the U.S. Department of Defense to collect lessons learned, categorize them and conduct exercises to share these lessons and propagate best practices.

In conclusion, when feasible, the development of documentation from informal information sheets for self-usage to large databases for shared access is advisable, as long as the involved activities are *repeatable enough* to justify the related investment. Although a cumbersome process, the collection of lessons learned

needs to happen quickly in any project environment, in order to guarantee maximum accuracy and minimal loss of information. Consolidation can then take longer in order to ensure efficacy, maximize reception, and foster building of an institutional knowledge base which resides within the company (or across multiple companies in the case of knowledge sharing and cooperation) processes and procedures, rather than individuals.

***Solution #12: Guidelines and templates***

Formal guidelines and templates may also support coordination across borders. Within the humanitarian sector, a good example of comprehensive guidelines developed across the different phases of a disaster is the International Search and Rescue Advisory Group (INSARAG) guidelines, which cover preparedness, mobilization, operations, and demobilization.

These guidelines are not hard and fast rules but more the baseline/default position, which should be tailored in light of specific disaster situations (Tatham & Spens, 2014). All of our interviewees from the humanitarian area mentioned at length the importance of guidelines, templates and standards for preparedness and reduction of ramp-up time in the various humanitarian organizations they have worked with. Some points of note include:

(i) Guidelines or manuals need to be constantly reviewed and updated – Neruda & Mistral are currently assisting the Chilean government in testing the newest manuals on disaster planning procedures.

(ii) Proper training of personnel is needed for guidelines to have maximum effect – this ties in with the common training and qualification regime under the INSARAG model (Tatham and Spens, 2014).

(iii) Adaptation of any guidelines or template to the changing, dynamic disaster situation at hand is crucial.

(iv) Guidelines should cover expedited procedures during disaster periods, e.g. Red Cross has procedures to expedite procurement, while U.N. World Food Program (WFP) allows expedited fund release taking no more than one week, as shared by Preto and Mariano.

Lastly, the benefits of sharing formulated guidelines and templates include accelerating learning processes and knowledge transfer, as well as providing continuity within organizations (Tomasini & Van Wassenhove, 2009). All of the interviewees share this view. Rory was exceptionally strong on this point sharing that FEMA used a database system borrowed from the US Department of Defense to manage best practices and lessons learned, and conduct joint training exercises based on these practices.

This ties in with the benefits of the Oxfam, U.N.-backed Helios project supporting software usage for increased collaboration and coordination in emergency response. The project combines the long term goal of assisting standardization and harmonization of processes with supporting benchmarking to promote best practices (Blansjaar & Stephens, 2014).

A good example of template for emergency management is provided by the Florida State Emergency Response Team (SERT). The template includes a series of activities related to each specific type of disaster with required initiation time, responsible agency and completion tracking information on the side.

A similar kind of template could be developed by the company's individual business units to support mobilization procedures for project-driven supply chains. A more generic template for the company is discussed in the conclusion section of this paper.

***Solution #13: Physical proximity***

Some business units have put into place measures for physical proximity between some members of the supply chain, e.g. the dispatcher and the sales team. This enhances cooperation between the two functions. However, due to the nature of project-driven supply chains, separation of personnel across borders is unavoidable. In this case, frequent meetings of the relevant parties for reporting purposes are implemented both locally, for day-to-day operations control, and with the headquarters.

Within the humanitarian sector, a training solution has been developed in order to improve cooperation, even between personnel based across multiple locations.

"*People tend to know each other because they worked together in the last disaster and the disaster before that. They have developed some kind of trust. The guy from (a humanitarian organization) knows his counterpart from Red Cross, so they send emails to each other and chat over beer ... and that is how a lot of information gets exchanged.*" - Mariano

Relationship and trust building is crucial to effective coordination and implementation of any event, not just last-mile delivery as indicated in the section above. Ursa, Neruda & Mistral highlight the need for trust between the population and the authorities, in order to limit damage in a situation of chaos and panic. Adequately trained on-the-ground staff would be one solution. The ASEAN Coordinating Centre for Humanitarian Assistance (AHA) is training relief workers across the region through joint response drills to enable governments to take greater responsibility during disasters (Barnette & Walker, 2015).

Both Rory and Mariano point out how informal communication due to strong relationships leads to more efficient communication across agencies. Rory and Mariano also share how disaster simulation exercises (carried out by FEMA and WFP) are good means of building such trust across different agencies and personnel.

In conclusion, physical proximity is a key driver of successful coordination. In case this is not possible, dedicated training exercises can help generate trust and build relationships across the company (and its customers and suppliers), which will foster a more effective coordination during the actual execution of the project.

***Solution #14: Distribution frameworks***

Finally, the subdivision of a supply contract into different phases, each entailing specific objectives and requirements may also support coordination.

Given the breadth and depth of military supply chains, *segmentation* is a key strategy. The U.S. Department of the Army (2014a) segments the supply chain into four legs; Intracontinental, Intertheater, Intratheater and Tactical with different levels of responsibility. The classification is depicted in Figure 3.

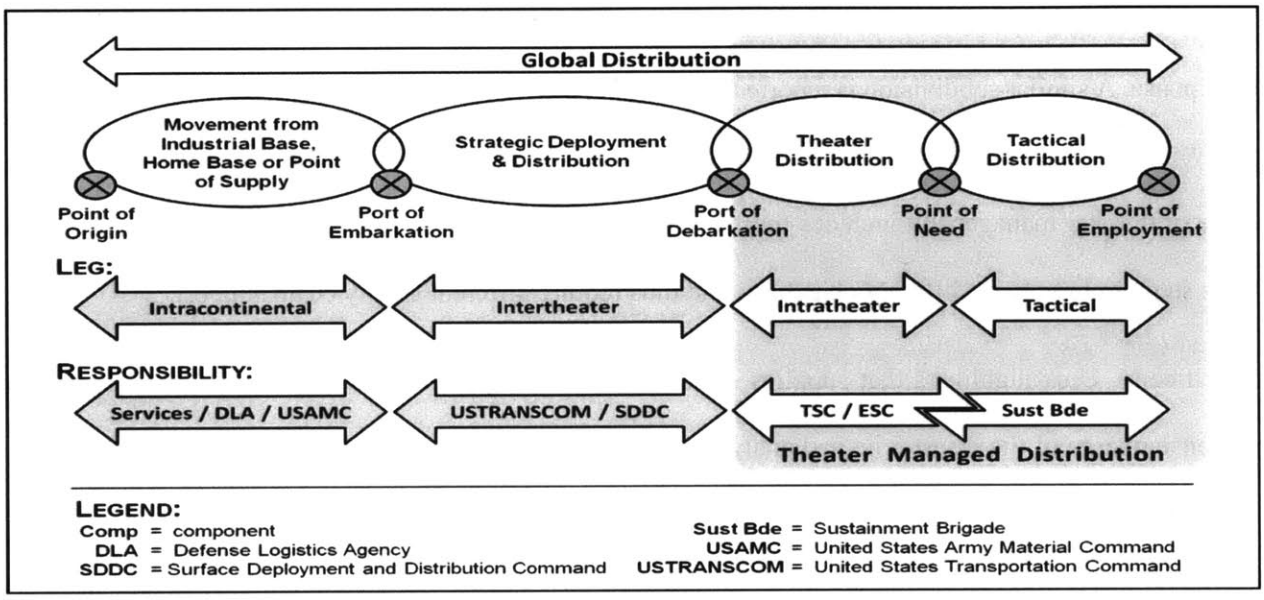


*Figure 3 - Global distribution. Source: Department of the Army (2014a)*

Henderson (2008, p. 19) highlights that logistics operations within a theater may be further differentiated according to the type of military operation. Military operations could be structured in four ways – Offensive, Defensive, Stability and Support. As shown in Figure 4, these four structures of operations would be supported by four types of logistic support, namely Maneuver support, Sustainment support, Management support and Administrative support.

| Types of Military OPNS | Offensive | Defensive | Stability | Support |
|---|---|---|---|---|
| Structure of Military OPNS | - Movement to Contact<br>- Attack<br>- Exploitation<br>- Pursuit | - Area Defense<br>- Mobile Defense<br>- Retrograded Operations | - Peace OPNS<br>- Foreign Internal Defense<br>- Security Assistance<br>- Humanitarian & Civic Assistance<br>- Support to Insurgences<br>- Combating Terrorism<br>- Noncombatant Evacuation OPNS<br>- Arms Control<br>- Show of Force | - Domestic Support OPNS<br>- Foreign Humanitarian Assistance<br>- Relief OPNS<br>- Support to Incidents Involving WMD<br>- Support to Civil Law Enforcement<br>- Community Assistance |
| Theater Progression | Immature | Distribution Network | | Mature |
| Types of Logistical Support OPNS | MANEUVER OPNS | SUSTAINMENT OPNS | MANAGEMENT OPNS | ADMINISTRATIVE OPNS |

*Figure 4 – Logistical support operations sliding scale. Source: Henderson (2008, p. 19)*

The subdivision provides a clearer understanding of the requirements, objectives and resources involved in each phase. A similar subdivision is reported in the humanitarian literature. Tomasini and Van Wassenhove (2009) talked about the Disaster Management Cycle, which was also mentioned by Ursa where the full cycle of disaster management includes four steps: Mitigation, Preparedness, Response and Rehabilitation. Each step or phase have different objectives and thus require different supply chain support.

Specifically, Ursa highlights that supplies selection and routing differed during the preparation and the response phases of the disaster he had analyzed. Tomasini and Van Wassenhove (2009) further highlight the Coordination Life Cycle, which is made up of three phases, namely *ramp-up*, *sustain* and *ramp-down*. They argue that matching the right coordination type (i.e. coordination by command, coordination by consensus and coordination by default) could increase the efficiency of the supply chain.

Wakolbinger and Toyasaki (2014) have argued that different phases in disaster relief (such as *preparation*, *immediate response* and *reconstruction*) present different challenges and require a different funding models.

As an impeccable planning and execution of the distribution processes is key to the success of any operation on the battlefield (Department of the Army, 2014a), replenishment and reporting activities are also clearly defined and follow a specific rhythm in accordance with the classification of Tactical, Operational or Strategic stages of the operation.

According to Henderson (2008, p. 45), the most common replenishment cycle in military logistics encompasses *Requirement* (i.e. what a unit needs to sustain itself for a 24-hour period), *Projection* (i.e. how many times the unit can be replenished within the 24 hours based on hauling and storage capacity) and *Forecast* (i.e. the excess demand requiring additional resources to prevent a shortfall). The repeatability and traceability embedded in the replenishment cycle constitute the true strength of military supply planning, once again provided the execution is faultless.

The segmentation strategy further extends within a theater for the supply planning and replenishment of specific items. Each item is categorized in order to allow for diversified strategies during the replenishment process. The most common categories are reported in Table 6 below.

*Table 6 - Classes of supply. Source: Department of the Army (2014b)*

| Description | Class |
|---|---|
| Subsistence. | I |
| Clothing, individual equipment, tentage, organizational tool sets and tool kits, hand tools, maps, and administrative and housekeeping supplies and equipment. | II |
| POL: petroleum fuels; lubricants; hydraulic and insulating oils; preservatives; liquid and compressed gasses; bulk chemical products; coolants; deicing and antifreeze compounds, together with components and additives of such products; and coal. | III |
| Construction materials, including installed equipment and all fortification/barrier materials. | IV |
| Ammunition of all types, including chemical and special weapons, bombs, explosives, mines, fuses, detonators, pyrotechnics, missiles, rockets, propellants, and other associated items. | V |
| Personal demand items (nonmilitary sales items). | VI |
| Major end items: a final combination of end products that are ready for their intended use, for example: tanks, launchers, mobile machine shops, and vehicles. | VII |
| Medical material, including medical-peculiar repair parts. | VIII |
| Repair parts (less medical-peculiar repair parts): all repair parts and components, to include kits, assemblies, and subassemblies — reparable and non-reparable — required for maintenance support of all equipment. | IX |
| Material to support nonmilitary programs, such as agricultural economic development, not included in Classes I through IX. | X |

In summary, an adequate segmentation framework accompanied by a detailed and meticulous planning process is one of the key factors leading to a coordinated supply chain and replenishment process within a highly uncertain, ever changing theater of operations, such as, in our case, the path of a project-driven supply chain.

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In the next chapter, we report a series of possible solutions to the challenges of project-driven supply chains in the chemical industry for the remaining category, (iii) Last-Leg.

## 7. Last-leg solutions

In this chapter, we report a series of possible solutions to challenges of project-driven supply chains regarding the last-leg, local portion of the supply chain. The last-leg portion of the supply chain includes all challenges faced by the company upon arrival at the port of the country in which the project is sited. The challenges would thus include "last-mile" problems, defined as the portion of transit from the final delivery center to the customer's door, some of which had been touched on in previous chapters. In order to do so, we summarize best practices identified from within the company, and humanitarian and military supply chain expertise into a range of three possible solutions which would together address the five last-leg challenges that we had identified in Chapter 4.

### 7.1 Brief overview of proposed solutions

**Five identified last-leg challenges**

Challenge #7: Remote destinations

Challenge #8: Extreme weather conditions

Challenge #9: Equipment unavailability

Challenge #10: Lack of storage capabilities

Challenge #11: Cultural differences

**Proposed solutions**

The three possible solutions reported in this chapter that addresses the above five challenges include:

***Solution #15: Centralized-logistics solutions provider.*** Designation of a centralized department offering transport solutions. The department develops a logistics concept and strategy based on

project site location and quantity of product to be delivered, and engages suitable logistics providers to navigate the geographical or infrastructural constraints of the last-leg delivery.

***Solution #16: Local expert presence.*** Ensure the knowledgeable and experienced ground personnel and experts in 'last-leg' delivery are involved in supply chain planning and implementation procedures within the company. This would ensure the availability of innovative solutions when required, and an eventual effective and smooth execution. The presence of these experts in the theater of operations is deemed necessary for the success of the supply chain, due to the many uncertainties inherent in last-leg deliveries.

***Solution #17: Relationship-building and asset-sharing.*** Develop ties with humanitarian organizations in order to leverage their expertise and assets, if available in the locale of operation, whilst creating a positive return for the company in terms of its public image.

As before, these proposed solutions – while not universally applicable – are possibilities worth considering when setting up a project-driven supply chain, as further explained below.

### 7.2 Detailed discussion of proposed solutions

The identified possible solutions to the last-leg project-driven supply chain challenges are reported in the following.

**<u>Solutions to Challenges #7 through #11</u>**

The following solutions help address the challenges of last-leg delivery in a foreign, often remote location, including lack of infrastructure, transportation equipment and storage facilities, adverse weather conditions, and cultural differences.

***Solution #15: Centralized-logistics solutions provider***

The sponsor company has a centralized department offering transport solutions. They develop a logistics concept and strategy based on project site location and quantity of product to be delivered. This department will then engage suitable logistics providers to navigate the geographical constraints. However, this service

was mentioned by only one of the interviewees. Some business units, for example, utilize their own fleet of transport for delivery.

In addition to the internal knowledge, Antiguo mentions he advises his clients to engage a local consultancy in order to help navigate a country's capabilities.

The military also has developed similar initiatives internally, on a regional basis. For example, the Adaptive Logistics Network Initiative (ALN), i.e. a central database which documents trustworthy African businesses and their capabilities, as described in the Cross-border chapter of this paper.

In summary, a solid centralized knowledge base integrated with local expertise on each occasion provides a compelling combination to navigate each destination country's logistic capabilities.

***Solution #16: Local expert presence***

In addition, company know-how needs be present on the ground in the form of experienced personnel. For example, one of the business units deploys personnel to be physically present in the country where the project is located, to participate in the implementation of the supply chain themselves.

This field level of knowledge may constitute a significant source of competitive advantage. For example, some business units have experienced personnel to ensure that in sunny climates, the chemical products are packed using black colored bags, to avoid extreme exposure to sun light. They would also ensure that, while in humid climates, transportation would be done in trucks, whether flatbed or Tautliners, that are well-covered to prevent exposure to rain water. Bags could also be shrink-wrapped to protect the product against moisture. The effectiveness of this shrink-wrap method in protecting materials is 95%.

In order to prevent the extremely low temperatures from affecting the materials, one of the business units has been able to transport liquid materials in winter by using specialized containers with heating coils in them, thus allowing the product to stay warm during transit. Another business unit with a project located in a region with high temperatures utilizes refrigerated loaders to transport their materials.

On a past project, a business unit made the decision to keep trained experts involved in the execution stage in order to address packaging and material handling in the country in which the project was located. The business unit views minimizing risks for their customers as good business: ensuring that the product performs as expected is part of their definition of high quality, and allows them to charge extra.

In the case above, flatbed trucks were used in place of Tautliners, which made unloading the trucks much slower than expected. To speed up unloading, tents covering the flatbed trucks were removed. However this meant that, if there was rain, the materials would be damaged as there was no cover. The trade-off was accepted based on the expectation that the climate was not rainy during that period of time.

Finally, on a particular project, one of the business units engaged an international logistics provider to search for warehouses for them in the locations where the projects were located. That said, there were instances where the logistics provider was unable to find a warehouse or storage facility. The business unit then decided to store the materials in lined containers. Other innovative storage solutions include bladder bags which are big plastic bags sitting in sea containers. Bladder bags were used by the business unit some 20 years ago, but had not been used since. New technology has made it possible for these bags to be made out of biodegradable material, which has made them an attractive option once more. The use of the bladder bags in one of the projects reduced transportation costs by 50% due to the elimination of ISO container leases and the costs of an empty backhaul.

That said, none of these innovative adaptations could have been possible without experts on the technical application of the materials and its properties, as well as on transportation equipment being in contact with each other and aware of the situation. This knowledge resides in individuals in the company rather than documentation or processes (what is often called *tacit knowledge*), and hence it is required, in parallel with the consolidation of each lessons learned, to get these personnel on the ground.

An effective parallel could be drawn with military convoy movement and fuel supply chains, for which the knowledge and experience of operating personnel combines and adds to the existing procedures in order to guarantee an effective, smooth execution.

***Solution #17: Relationship-building and asset-sharing***

Setting up a supply chain in a foreign country is a challenging task. Business units in the sponsor company have addressed this challenge in different ways. For example, one business unit has used an international logistics service provider that has direct experience in dealing with the people and culture of the target foreign country to handle the set-up of the business unit's supply chain in that country. Another business unit chose instead to transfer the foreign business to a sister business unit that is physically located in the country where the project is being carried out. One thing these two solutions have in common is that they rely on partners that either have existing relationships in the foreign country, or are in a better position to develop the relationships.

Local presence is often a highly debated issue within the military. When talking about local presence, Heath, who worked as a civilian supporting the U.S. Army, mentions *"U.S. footprint in the country helps facilitate the delivery within specs"*. Tom confirms an entity is required on the ground to support all local procurement and supply chain initiatives.

According to Ethan, having a local team with shared responsibilities, some of which include logistics, facilitates operations even in a restricted environment such as a submarine. Requirements would then be fed directly to a dedicated shore facility coordinating all procurement activities, given the limited communications available when underwater.

Being experienced in procurement and contracting, Tom suggests the use of *reachback contracts,* i.e. contracts signed by HQ personnel with suppliers in the country of origin, in order to reduce the workload of the designated officers within a theater (i.e. on site), and allow them to concentrate on the running of day-to-day operations. This strategy allows the number of deployed personnel to be adjusted according to

the resources available in the home operating country (Ausink, Werber Castaneda, & Chenoweth, 2011). The requirement to design an efficient strategy applies specifically to dealings with high levels of contracted support.

Eventually, expertise of staff available on site needs to be valued regardless of rank. Initiatives to confirm and evaluate expertise are regularly implemented on U.S. Army sites, as reported by Christian. This allows the Army to identify personnel with relevant knowledge or skills (even those who may at the time be assigned to a different job) and to designate them as *champions* for specific areas of expertise in their current site. These champions would be further developed or *built* in those areas of expertise. Initiatives may reveal opportunities, such as storage rearrangement and revision of inventory and replenishment strategies, which would otherwise go unexploited if site staff with relevant expertise had not identified them.

The humanitarian sector excels at this practice of identifying staff with specific areas of knowledge and expertise. Humanitarian supply chain managers create in advance a series of "social networks" of local personnel, to be leveraged during the execution of disaster response.

Beyond local-federal agency coordination, communication between central coordinating functions and local presence on the ground is a crucial factor of success for any disaster response. Ursa, Rory, Protos, Neruda & Mistral all highlight the importance of *regular decision-making meetings* with local representation to be conducted on a daily basis during the disaster unfolding. It is of utmost importance for agencies to realize ground staff are key *knowledge holders*, and are the ones best positioned to assess the disaster situation and the impact of the planned response. Additionally, they will also be the ones implementing all the initiatives involved in the response.

That said, there is often no time during the immediate response to a disaster to relay information and wait for decisions. Accordingly, Neruda & Mistral strongly advocate allowing *improvisation*. It is such understanding that also led to U.S. disaster response reforms favoring small, decentralized approaches to crisis mitigation (Altay & Labonte 2014).

Eventually, in the delivery of aid in a mega disaster, the last mile also typically presents a challenge (Fenton, Goodhand & Vince 2014). The effectiveness of last-mile delivery in disaster relief often relies on support provided by local authorities and voluntary individuals (Tomasini & Wassenhove, 2009). Ursa, Mariano, Neruda & Mistral term these networks "social capital", and refer to such practices as "social reliance". While not an easy task, efforts to identify, train and maintain long-term relationships with local partners improve last-mile delivery, as shown by case studies of Indonesian NGOs (Lu, Goh and De Souza 2013).

Cooperation between military, humanitarian and commercial organizations in terms of supply chain have been encouraged but more can be done in terms of practice (Seipel, 2011). Collaborative initiatives between humanitarian and military operations supporting the local population during disasters, through the use of specialized military vehicles, have been recorded in the past (Cross, 2014). The Red Cross has a central depot of vehicles, which could be rented to different governments. The U.N. World Food Program (WFP) owns fleets of aircraft and vehicles as well. In fact, the WFP offers customs clearance, transportation and warehousing services through the Logistics Cluster to other humanitarian organizations in remote countries like Syria (Heaslip, 2014). These agencies could achieve higher utilization of their assets by enhancing sharing opportunities. This could also prove highly beneficial for private sector companies requiring to ramp up project-driven supply chains in remote locations.

However, there are significant differences in operating priorities between humanitarian and commercial organizations. Whereas a commercial organization's main objective is to establish the grounds for future profits, the humanitarian organization would only look at the immediate scenario, creating a conflict of interests hard to address during the course of an operation (Larson, 2011). That said, humanitarian supply chains have steadily incorporated large logistics companies like TNT and DHL, which have set up specialized humanitarian relief departments; and UPS, Maersk, Agility forming the Logistics Emergency team with the WFP and World Economic Forum (WEF). Such cooperation could lead not only to sharing equipment, but also to sharing of whole facilities such as emergency response centers. The Florida State Emergency Response Team (SERT) shares their warehouse with a water bottling company based on the

arrangement that they would be able to procure all the bottled water in the warehouse once there is an emergency (Goentzel, 2016). Commercial organizations could set-up and donate a shared warehouse where the two organizations would co-exist, sharing know-how by staff rotation and cross training. Quick and efficient response to any disaster could be arranged due to the larger number of employees (of both organizations). This arrangement would also generate positive image for the commercial organization.

In conclusion, the issue is not as much about whether local presence is required but how to leverage field staff capabilities to support the supply chain as much as possible. The ideas listed above may represent valuable insights for commercial organizations looking for opportunities to do so whilst improving their project-driven supply chain last-mile delivery performance in relation to external, uncertain events.

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In the next chapter, we combine all proposed solutions into a simple template of aspects worth considering when setting up a project-driven supply chain in the chemical industry.

## 8. Mobilization template

Based on the challenges identified in mobilizing project-driven supply chains in the chemical industry, in this chapter, we rearrange the previously identified issues and solutions (from all the sources previously discussed) into a standalone template for the sponsor company to use as a high-level checklist for mobilization of project-driven supply chains within the chemical industry.

The template offers a set of *Mobilization-related questions*, arranged following the three categories used throughout this document; (1) Business-specific, (2) Cross-border, and (3) Last-leg; six areas, mirroring the challenges of project-driven supply chains identified in the previous chapters; and seventeen sub-areas, corresponding to the solutions to each of the previously discussed challenges. The high-level mobilization template is reported in Table 7.

*Table 7 - Template for mobilization of project-driven supply chains*

| **1.Business-specific** | | |
|---|---|---|
| Area | Sub-area | Mobilization-related questions |
| 1.A Demand and supply management | *1.A.1 Pre-planning processes* | *- Is there an adequate S&OP process in place?*<br>*- Has demand been "sensed" (monitored) based on information coming directly from the customer?*<br>*- Has demand been shaped to meet supply?*<br>*- Has demand been quantified and with what level of uncertainty?*<br>*- Has supply chain personnel been involved in the S&OP process?*<br>*- Have decisions been made on capacity investment or divestment accordingly?* |
| | *1.A.2 Flexible and upfront contracting* | *- Have key carriers been vetted?*<br>*- Has the option of flexible transportation contracts been discussed with key carriers?*<br>*- Have alternative courses of action been considered?*<br>*- Have alternative replenishment procedures been developed accordingly?*<br>*- Are quick funding solutions in place for emergency replenishment?* |
| | *1.A.3 Vendor managed inventory* | *- Is the customer high uncertainty, low-lead time?*<br>*- Can holding inventory close to the customer be considered a viable option to achieve a quick response to changes in demand?* |
| | *1.A.4 Modularity* | *- What is the required equipment for the supply?*<br>*- Is such equipment available or has it been previously used within the company?*<br>*- How can the equipment be transported?*<br>*- Are there alternative usages for the equipment after the project is completed?*<br>*- How will the equipment be reused / disposed of?* |
| | *1.A.5 Systems integration* | *- Is the customer internal or external to the company?*<br>*- What is the level of trust and relationship with the customer and / or key carriers?*<br>*- Is there a system in place to streamline order processing, export, inventory management, invoicing and payments with the customer and / or key carriers?*<br>*- What is the level of visibility over the supply chain?* |
| 1.B Customer contracts | *1.B.1 Provisions within the contract* | *- Is the customer likely to request changes in scheduled delivery times?*<br>*- What is the likely magnitude of these changes?*<br>*- Have these potential changes been discussed with the customer and / or included in the contract price?* |
| | *1.B.2 Risk-sharing mechanisms* | *- Is the customer expecting the company to take on all the risk?*<br>*- Is the customer prepared to discuss mechanisms to quantify response to unforeseen circumstances including sharing of the related risks?* |
| 1.C Competitive positioning | *1.C.1 Continuous reorganization* | *- What is the value proposition of this supply contract?*<br>*- Is the current organizational structure best suited to allow an efficient delivery of the desired value proposition?* |

| **2.Cross-border** | | |
|---|---|---|
| Area | Sub-area | Mobilization-related questions |
| 2.A Regulations and compliance | *2.A.1 Centralized knowledge base, institutional knowledge building and documentation* | *-Is there a centralized knowledge base on country-specific regulations?*<br>*- Can this be easily accessed by relevant personnel?*<br>*- Is there a process in place to actively update and disseminate this information?* |
| 2.B Coordination across the supply chain | *2.B.1 Specific supply chain roles* | *- Has a role and responsibility matrix been developed for the project?*<br>*- Have specific supply chain roles been discussed and implemented for the project?*<br>*- Have the most suitable candidates been identified and informed of their roles and responsibilities?*<br>*- Is a structured decision-making process in place for the project?* |
| | *2.B.2 Knowledge transfer, institutional expertise retention and documentation* | *- Does the key personnel have knowledge of the characteristics of the product?*<br>*- Has the key personnel received formal training in setting up project-driven supply chains?*<br>*- What documentation needs to be preserved at the end of the project?* |
| | *2.B.3 Guideline and templates* | *- What guidelines and templates are useful for the project?*<br>*- What guidelines and templates need to be developed specifically for the project?*<br>*- How are these documents going to be stored?*<br>*- How often are these documents going to be updated?*<br>*- How will these documents be made available to personnel?* |
| | *2.B.4 Physical proximity* | *- Are the key stakeholders located in close proximity?*<br>*- Have the key stakeholders collaborated before?*<br>*- Has a training / trust-building exercise been considered prior to the start of the project?* |
| | *2.B.5 Distribution frameworks* | *- What are the different phases of the project?*<br>*- What are the reporting and communication requirements for each phase?*<br>*- What is the selected communication "rhythm" (frequency) for each phase?* |
| **3.Last-leg** | | |
| Area | Sub-area | Mobilization-related questions |
| 3.A Transportation, storage and delivery within the last-mile | *3.A.1 Centralized-logistics solutions provider* | *- Is there a centralized department offering transportation solutions? If, so, has it been contacted?*<br>*- Is there a logistics strategy in place based on the project site's location and quantity of product to be delivered?*<br>*- Have suitable logistics providers been identified and engaged to navigate the constraints of last-leg delivery?* |
| | *3.A.2 Local expert presence* | *- Has the most experienced ground personnel been identified and assigned to the project?*<br>*- Is such personnel going to be based* in loco*?* |
| | *3.A.3 Relationship-building and asset-sharing* | *- Have trusted organizations operating in the area been identified and screened for logistics capabilities?*<br>*- Has the company ever collaborated with any of them in the past?*<br>*- Do such companies own any asset or expertise that may support the execution of the project?* |

## 8.1 Mobilization process

The mobilization template is intended to be used as a checklist to confirm most critical areas have been addressed in setting up a project-driven supply chain. Accordingly, the template can be used as both a guideline for planning the mobilization of a new contract requiring the setup of a project-driven supply chain, and, subsequently, as a validation tool to confirm the mobilization process has been thoroughly completed.

In order to ensure an effective utilization of the template, we recommend following a three-step process for the mobilization of project-driven supply chains:

*(1)* *Mobilization planning* – Using the template as a guideline, the contract manager (i.e. the person in charge of delivering the contract) performs the following actions:

*i.* collects the mobilization requirements;

*ii.* compiles the requirements into a mobilization plan, inclusive of necessary actions, deadlines and responsible parties; and

*iii.* initiates the required mobilization processes

*(2)* *Mobilization execution* – The contract manager ensures the mobilization is completed within the required timeframe.

*(3)* *Mobilization gate review* – The contract manager collects all the documentation prepared during mobilization and presents them to the executive review team (i.e. a team of stakeholders and/or senior managers called upon reviewing the contract progress). The executive review team reviews each of the mobilization-related documents against the seventeen sub-areas of the mobilization-template and scores each item, P or F ("Pass" or "Fail"). The mobilization gate review process has three possible outcomes:

*i.* *Approved (A):* All "Pass".

- The executive review team is satisfied all seventeen sub-areas of the mobilization template have been addressed to the required level of attention.

- The contract manager is authorized to move to the execution phase of the contract.

ii. *Conditionally Approved (CA):* Up to three "Fail".

- The executive review team is satisfied most sub-areas of the mobilization template have been addressed to the required level of attention.
- The executive review team reviews and approves an action plan to address each sub-area not meeting the required standard ("Fail").
- The contract manager is authorized to move to the execution phase of the contract, provided a subsequent review is scheduled to verify the rectification plan is completed within a predefined timeframe.

iii. *Not Approved (NA):* More than three "Fail".

- The executive review team is not satisfied most sub-areas of the mobilization template have been addressed to the required level of attention.
- The contract manager is not authorized to move to the execution phase of the contract.
- A new mobilization gate review meeting is scheduled to verify the mobilization process is completed up to the executive team's satisfaction.

The above procedure has been developed based on the authors' experience, and hence it is intended only as a starting point for the company to adopt the mobilization template within its managerial processes. Details such as specific roles and responsibility of management have not been included, in order for the company to integrate the mobilization template within its management review and approval processes. This should include predefined roles for contract manager and executive review team.

We recommend the integration process is completed after a trial implementation period, in order for the company to collect feedback on the effectiveness of the procedure and to be able to successfully adapt it to its internal structure.

Eventually, the mobilization template is meant to be a living document, updated regularly in accordance with any additional requirements of the company, the customer or the industry as a whole. Adequate processes for record keeping and periodic review will ensure the document is adopted and eventually becoming "second nature" for supply contract managers and management in general.

## 9. Final considerations

This thesis aimed at identifying suitable mobilization practices in order to ensure a more efficient, effective and easily repeatable setup of project-driven supply chains in the chemical industry.

Accordingly, we have reviewed some of the literature related to project-driven supply chains, including military and humanitarian applications, discussed elements of how project-driven supply chains are currently managed within the sponsor company, and related them to how project-driven supply chains are managed in the humanitarian and military fields.

In doing so, we have identified a set of eleven challenges deemed critical to setting up project-driven supply chains in the chemical industry, subdivided them into three categories and related them to seventeen possible solutions aimed at facilitating the setup of project-driven supply chains in the chemical industry.

Next, we draw a series of conclusions on the applicability of our research within the chemical industry and beyond. Specifically, these include: (1) additional factors deemed required to achieve a successful change management process and consolidation of the achieved improvement, (2) applicability of our research within the chemical industry, and (3) future steps towards applicability of our research beyond the chemical industry.

### 9.1 Factors towards successful change

A successful completion of the mobilization process described in Chapter 8, using the mobilization template, is only the start of an efficient, effective and repeatable setup of project-driven supply chains in any industry.

First of all, in order to provide a repeatable setup, it is of utmost importance that the whole company, from the leadership down, commits to an efficient delivery of project-driven supply chains. Lack of leadership drive will often leave improvement initiatives unfinished, and anything less than full commitment on such initiatives may produce unsatisfactory results.

Furthermore, the initiative needs to be translated into more detailed processes and procedures, including well defined roles and responsibilities for the implementation of the change across the organization, monitoring of the achieved results and strategic review of the process within the allocated timeframe.

Finally, the consolidation of lessons learned processes must apply to the mobilization process and template itself. Given the unique and changing nature of project-driven supply chains, we did not find total standardization a suitable way to conduct these processes. We believe *lessons learned* need to be consolidated at every level of the organization, starting from the field, all the way up to the corporate headquarters, in order to ensure *repeatability*, *alignment*, and *continuous improvement* of the mobilization process.

### 9.2 Applicability to the chemical industry

The presented mobilization approach for project-driven supply chains has been developed based on information acquired from the sponsor company. Hence, although we have strived to keep the process general and high-level, the proposed solutions tend to be tailored to the needs of the sponsor company.

Nonetheless, we encourage other players within the chemical industry to adopt and challenge our proposed approach, especially those chemical supply chains facing similar challenges as the ones highlighted in Chapter 4. Even a healthy, innovation-focused competition will allow the industry to continue evolving towards delivering its products safely, effectively and efficiently across the globe.

### 9.3 Applicability beyond the chemical industry

In conclusion, we hope our research serves as a starting point for a broader and ongoing discussion on project-driven supply chains within the chemical industry and beyond. It is definitely in our vision to spur a rich dialogue between commercial and humanitarian organizations on the subject, leading to a close collaboration aimed at a more effective utilization of the extensive know-how and physical capabilities available on both sides.

Hopefully, within the context of increased desire for cost-efficiencies and sharing of knowledge and information, a successive involvement of military organizations, whose processes and training practices would be highly valuable in high uncertainty environments, will also bring value to the discussion. Public corporations willing to collaborate with the military may face some questions from their shareholders. However, both sectors could benefit from cooperation towards improving the effectiveness of processes and their execution capabilities, and facilitate the exchange of knowledge and maybe even personnel.

Eventually, we envisage there could be potential to extend our research to be applied to a series of project-dominated industries, such as, for example, construction and infrastructure, ship-building, rail, and aerospace. We welcome any application and adaptation of our research to alternative industries and eagerly await any feedback on the achieved results.

## References


Aloini, D., Dulmin, R., Mininno, V., & Ponticelli, S. (2015). Key antecedents and practices for Supply Chain Management adoption in project contexts. *International Journal of Project Management, 33*(6), 1301-1316. doi: http://dx.doi.org/10.1016/j.ijproman.2015.03.013

Altay, N., & Labonte, M., (2014). Humanitarian logistics and the cluster approach: global shifts and the US perspective. In Christopher, M., & Tatham, P., (2nd Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 97-114). London: Kogan Page Limited.

Ausink, J. A., Werber Castaneda, L., & Chenoweth, M. E. (2011). *Air Force Contingency Contracting - Reachback and other opportunities for improvement*. RAND Corporation.

Baiden, B. K., Price, A. D. F., & Dainty, A. R. J. (2006). The extent of team integration within construction projects. *International Journal of Project Management, 24*(1), 13-23. doi: http://dx.doi.org/10.1016/j.ijproman.2005.05.001

Barnette, M., & Walker, P. (2015). Regime change for humanitarian aid. *Foreign Affairs*(July/August 2015).

Blansjaar, M., & Stephens, F., (2014). Information technology in humanitarian supply chains. In Christopher, M., & Tatham, P., (2nd Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 57-76). London: Kogan Page Limited.

Brady, T. (2011). Creating and sustaining a supply network to deliver routine and complex one-off airport infrastructure projects. *International Journal of Innovation and Technology Management, 08*(03), 469-481. doi: doi:10.1142/S0219877011002362

Carr, D. F. (2009, 2 July, 2009). How the military is unifying communications and collaboration. *Defense Systems*.

Christopher, M., & Tatham, P. (2011). *Humanitarian logistics. [electronic resource] : meeting the challenge of preparing for and responding to disasters*: London ; Philadelphia, PA : Kogan Page, 2011.

Cottrill, K. (2011). Unexplored Territory in the Globalization Map. Retrieved from http://blog.mytmc.com/global/unexplored-territory-in-the-globalization-map/

Cross, T., (2014). Disaster agencies and military forces: not such strange bedfellows after all!. In Christopher, M., & Tatham, P., (2nd Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 257-273). London: Kogan Page Limited.

Department of the Army. (2014a). Army Theater Distribution. *Army Knowledge Online..*

Department of the Army. (2014b). General Supply and Field Services Operations. *Army Knowledge Online*.

Fearne, A., & Fowler, N. (2006). Efficiency versus effectiveness in construction supply chains: the dangers of "lean" thinking in isolation. *Supply Chain Management: An International Journal, 11*(4), 283 - 287.

Fenton, G., Goodhand, M., & Vince, R., (2014). What next for humanitarian logistics? In Christopher, M., & Tatham, P., (2nd Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 235-256). London: Kogan Page Limited.

Gadde, L.-E., & Dubois, A. (2010). Partnering in the construction industry—Problems and opportunities. *Journal of Purchasing and Supply Management, 16*(4), 254-263. doi: http://dx.doi.org/10.1016/j.pursup.2010.09.002

Goentzel, J., & Spens, K. (2011). Humanitarian logistics in the United States: supply chain systems for responding to domestic disasters *Humanitarian Logistics*. Philadelphia, PA: Kogan Page.

Heaslip, G., (2014). The increasing importance of services in humanitarian logistics. In Christopher, M., & Tatham, P., (2nd Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 175-187). London: Kogan Page Limited.

Henderson, J. H. (2008). *Military logistics made easy: concept, theory, and execution*: AuthorHouse.

Jomini, A. H., (1862). *The art of war.* Philadelphia, PA: J. B. Lippincott & Co.

King, A. R., Moss, Z. H., & Pittman, A. Y. (2014). Overcoming Logistics Challenges in East Africa. *Army Sustainment, 46*(1), 28-31.

Leiphart, C. L. (2001). Creating a military supply chain model. *Army Sustainment Magazine, 33*(4).

Love, P. E. D., Irani, Z., & Edwards, D. J. (2004). A seamless supply chain management model for construction. *Supply Chain Management: An International Journal, 9*(1), 43-56. doi: doi:10.1108/13598540410517575

Lu, Q., Goh, M., & De Souza, R., (2014). Emergency preparedness: experience of international humanitarian organizations in Southeast Asia. In Christopher, M., & Tatham, P., (2nd Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 175-187). London: Kogan Page Limited.

Moore, D., & Taylor D., (2011). Humanitarian logistics professionalism. In Christopher, M., & Tatham, P., (Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 179-199). London: Kogan Page Limited.

Naylor, B. J., Naim, M. M., & Berry, D. (1999). Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain. [Article]. *International Journal of Production Economics, 62*, 107-118. doi: 10.1016/S0925-5273(98)00223-0

Perez-Franco, R. (2016). *Rethinking your supply chain strategy: a brief guide*. Cambridge, MA: MIT Supply Chain Strategy Lab.

Pettit, S., & Beresford, A., (2005) Emergency Relief Logistics: An evaluation of military, non-miltary and composite response models, *International Journal of Logistics: research and applications*, 8(4), 313-331.

Pesämaa, O., Eriksson, P. E., & Hair, J. F. (2009). Validating a model of cooperative procurement in the construction industry. *International Journal of Project Management, 27*(6), 552-559. doi: http://dx.doi.org/10.1016/j.ijproman.2008.10.007

Potts, K. (2009). From Heathrow Express to Heathrow Terminal 5: BAA's Development of Supply Chain Management *Construction Supply Chain Management* (pp. 160-181): Wiley-Blackwell.

Rubin, H. J., & Rubin, I. (2005). *Qualitative Interviewing: The Art of Hearing Data*: Sage Publications.

Seidman, I. (2006). *Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences*: Teachers College Press.

Seipel, J., (2011). The impossible interface? Combining humanitarian logistics and military supply chain capabilities. In Christopher, M., & Tatham, P., (Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 215-232). London: Kogan Page Limited.

Seipel, J., & Heaslip, G., (2014). The impossible interface? Combining humanitarian logistics and military supply chain capabilities. In Christopher, M., & Tatham, P., (2nd Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 215-234). London: Kogan Page Limited.

Stake, R. E. (2013). *Multiple Case Study Analysis*: Guilford Publications.

Tatham, P., & Hughes K., (2011). Humanitarian logistics metrics: where we are and how we might improve. In Christopher, M., & Tatham, P., (Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 65-84). London: Kogan Page Limited.

Tatham, P., & Spens, K., (2014). Cracking the humanitarian logistic coordination challenge: some pointers from the International Search and Rescue Advisory Group and the Foreign Medical Teams In Christopher, M., & Tatham, P., (2nd Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 77-96). London: Kogan Page Limited.

Thomas, A. S., & Kopczak, L. R. (2005). From logistics to supply chain management: the path forward in the humanitarian sector: Fritz Institute.

Tomasini, R. M., & Van Wassenhove, L. N. (2009). *Humanitarian logistics*: Houndmills, Basingstoke ; New York, NY : Palgrave Macmillan, 2009.

Turner, J. R., & Müller, R. (2003). On the nature of the project as a temporary organization. *International Journal of Project Management, 21*(1), 1-8. doi: http://dx.doi.org/10.1016/S0263-7863(02)00020-0

Vrijhoef, R., & Koskela, L. (2000). The four roles of supply chain management in construction. *European Journal of Purchasing & Supply Management, 6*(3–4), 169-178. doi: http://dx.doi.org/10.1016/S0969-7012(00)00013-7

Wakolbinger, T., & Toyasaki F., (2014). Impacts of funding systems on humanitarian operations. In Christopher, M., & Tatham, P., (2nd Ed.), Humanitarian Logistics: *Meeting the Challenge or Preparing for and Responding to Disasters*. (pp. 41-53). London: Kogan Page Limited.

Xue, X., Li, X., Shen, Q., & Wang, Y. (2005). An agent-based framework for supply chain coordination in construction. *Automation in Construction, 14*(3), 413-430. doi: http://dx.doi.org/10.1016/j.autcon.2004.08.010

Zook, C., & Allen, J. (2011). *Repeatability*. Boston, MA: Harvard Business Review Press.