



ORIGINAL RESEARCH ARTICLE / ÖZGÜN ARAŞTIRMA MAKALESİ



Copyright@Author(s) - Available online at dergipark.org.tr/en/pub/igusbd.
Content of this journal is Licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 (CC BY-NC-ND) International License.

A Design of Relief Logistics System by Axioms

Yardım Lojistiği Sisteminin Aksiyomlarla Tasarımı

Ozan ATEŞ 

Abstract

Aim: This study scientifically addresses aid logistics operations, a subfield related to disaster management. It aims to conduct a design study that will guide those in authority. The study is in line with the classical logistics flow, with a value-oriented lean perspective, and eliminates processes that are not beneficial to disaster victims and include waste. The application of the axiomatic design approach in logistics, particularly in relief logistics, is relatively new and is expected to contribute to the existing literature gap in this area.

Method: This study presented a complete, separate, waste-free design structure for aid logistics activities using the Independence Axiom from the Axiomatic Design (AD) principles as a method. Independence action is a scientific methodology based on the design of design steps as separate as possible from each other. While creating the design structure in question, the dimensions of classical logistics were taken into consideration and the lean logistics perspective was utilized. In addition, current literature was effectively utilized in defining aid logistics design steps.

Results: The issues experienced after the earthquakes that occurred on February 6, 2023 and affected Turkey and Syria showed that there was no organizational awareness regarding aid logistics. When the collection and dispatch of aid materials after the earthquake was observed, it was seen that this operation was not carried out correctly and the necessity of such a study was realized.

Conclusion: The design presented has been presented as a horizontal hierarchy, simple, suitable for logistic flow, easy to understand and implement design study. Research on current literature has been guiding on what the design steps should be. For future studies, it is recommended that AT approaches be applied in other areas of disaster logistics. Correct prioritization of rescue activities, correct transfer of disaster victims to shelter areas, and management of wastes resulting from disasters are areas that can be improved with AT approaches.

Keywords

Relief logistics, axiomatic design, lean logistics, independence axiom, logistics

Asst. Prof., Istanbul Gedik University,
Engineering Faculty, Industrial
Engineering Department, Istanbul,
Turkey.

✉ ozan.ates@outlook.com.tr

Geliş/Received: 24.03.2025

Kabul/Accepted: 09.09.2025

Öz

Amaç: Afet yönetimi ile ilgili olarak bir alt alan olan yardım lojistiği operasyonlarının bilimsel bir şekilde ele alındığı bu çalışmada otorite sahiplerine yol gösterebilecek niteliğe sahip bir tasarım çalışmasının yapılması hedeflenmiştir. Afetzedelere faydası olmayan, israf içeren süreçlerin ayıklandığı, değer odaklı yalın bakış açısında sahip ve klasik lojistik akışa uygun bir çalışma yapılması amaçlanmıştır. Aksiyomatik tasarım yaklaşımının genel olarak lojistik alanında, özel olarak ise relief lojistik alanında kullanımı çok yenidir ve bu yönü ile literatürdeki boşluğa katkı sağlayacaktır.

Yöntem: Bu çalışmada yöntem olarak Aksiyomatik Tasarım (AT) prensiplerinden Bağımsızlık Aksiyomu kullanılarak yardım lojistiği faaliyetleri için eksiksiz, ayırık, israflardan arındırılmış bir tasarım yapısı ortaya konulmuştur. Bağımsızlık aksiyonu, tasarım adımlarının olabildiğince birbirinden ayırık tasarlanmasını esas alan bilimsel bir metodolojidir. Söz konusu tasarım yapısı oluşturulurken klasik lojistiğin boyutları göz önüne alınmış ve yalın lojistik perspektifinden yararlanılmıştır. Ayrıca yardım lojistiği tasarım adımlarının tanımlanmasında güncel literatürden etkin bir şekilde yararlanılmıştır.

Bulgular: 6 Şubat 2023 tarihinde meydana gelen ve Türkiye ile Suriye'yi etkileyen depremler sonrasında yaşanan sorunlar, yardım lojistiği konusunda örgütsel farkındalığın oluşmadığını göstermiştir. Deprem sonrası yardım malzemelerinin toplanması ve sevk işlemleri gözlemlendiğinde bu operasyonun doğru bir şekilde sürdürülmediği görülmüş ve böyle bir çalışmanın gerekliliği fark edilmiştir.

Sonuç: Ortaya konmuş olan tasarım, yatay hiyerarşiye sahip, yalın, lojistik akışa uygun, anlaşılması ve uygulaması kolay bir tasarım çalışması olarak ortaya konmuştur. Güncel literatür üzerinde yapılan araştırmalar tasarım adımlarının neler olması gerektiği hususunda yol gösterici olmuştur. Gelecek çalışmalar için AT yaklaşımlarının afet lojistiğinin diğer alanlarında da uygulanması önerilmektedir. Kurtarma faaliyetlerinin doğru bir şekilde önceliklendirilmesi, afetzedelerin barınma bölgelerine doğru bir şekilde transfer edilmesi ve afet sonrası ortaya çıkan atıkların yönetimi gibi alanlar AT yaklaşımları ile iyileştirilmesi mümkün olan alanlardır.

Anahtar Kelimeler

Yardım lojistiği, aksiyomatik tasarım, yalın lojistik, bağımsızlık aksiyomu, lojistik

1. Introduction

Before the shock of the 7,7 magnitude earthquake, whose epicenter was in the Pazarcik district of Kahramanmaraş, occurred on 06.02.2023 at 04.17, another 7,6 magnitude earthquake occurred in the same region, this time in the Elbistan district of Kahramanmaraş, on the same day at 13.24. The earthquake affected 12 cities in Turkey and the cities of southern Syria, and so far, 50,783 people in Turkey and 8,476 people in Syria have been reported to have lost their lives and injured more than 122,000. The main roads reaching the province of Hatay, which was one of the cities most negatively affected by the earthquake, became unusable for a while, the ground of the city's only airport was severely damaged and flights were cancelled. It was not possible to use the port during this period due to the fire that occurred as a result of the containers overturned in the Iskenderun port, which is the only port of Hatay, and which lasted for 3 days. In addition to this information, the railways could not be used because the rails were broken at several points on the railways in the city. The city became almost inaccessible by land, sea and air, and therefore the aid and rescue teams were able to intervene in the city too late. The few usable roads could not be used effectively due to the traffic created by the disaster victims who wanted to leave the city and the aid convoys who wanted to reach the city.

The second major problem was the inadequacy of the rescue teams due to the earthquake that affected a very large area and the adverse conditions due to the winter conditions. For these reasons, the survivors under the rubble could not be reached in time, and this caused an increase in the death toll. In order to save the survivors under the rubble, the inability of these vehicles to make correct prioritization in rescue activities has been the subject of intense criticism due to the insufficient number of construction machines that will remove the construction rubble and the number of operators who will use them.

The third major problem arose at the point of delivering the collected aid to the earthquake victims in a timely, requirement-oriented and adequate manner. From the first moments of the earthquake, citizens in many cities began to deliver the aid they collected to public and private institutions. aids; Efforts were made to reach the earthquake zones through the Disaster and Emergency Management Presidency, Red Crescent, municipalities, governorships, district governorships and non-governmental organizations. Although the incoming physical aids were classified according to their types in the collection areas and tried to be loaded on the vehicles going to the region, there was no qualified personnel to direct this operation and there was no process workflow to follow for the collection

and classification of aids. In addition to this situation, intense disruptions arose in the activities in question due to the fact that the earthquake victims were not aware of the aid reaching the earthquake zones and there was no coordination regarding where, how and by whom the aid vehicles reaching the earthquake regions would be emptied and distributed to the earthquake victims. Moreover, since the requirements of the earthquake victims were not determined correctly, inconsistencies arose between the requirements and outgoing aid.

These earthquakes and the disruptions that followed revealed that disaster logistics operations were not carried out in a conscious and planned manner. Within the scope of relief logistics, it was deemed necessary to conduct a study that would guide the authorities on this issue, eliminate the problems experienced in the earthquake disaster in question, such as lack of coordination, and cover the processes from collecting aid to delivering this aid to the relevant disaster victims. As a methodology, the Independence Axiom methodology, one of the axiomatic design approaches, was preferred. The biggest reason for choosing this method is that the ideal relief logistics operation design steps should be as independent of each other as possible.

The author presented a literature research on Axiomatic Design covering the years 2012 - 2022 in his relevant work. Accordingly, of the 90 publications closely related to the subject, 45 are only about the independence axiom, 34 are only about the information axiom, and 11 are about both methodologies. In the same literature research on the areas where axiomatic design is used, only 3 of the 90 publications on the subject are related to logistics - supply chain. As can be seen, there is a gap in the literature regarding the use of axiomatic design in the field of logistics - supply chain (Ateş, 2023). It seems that the use of AD principles in more logistics-related fields will contribute to the literature.

Some facilities may not be accessible for a while after the disaster. Due to the inaccessibility of these opportunities, it will be an important factor that ensures the sustainability of the operation healthily if disaster logistics operations are affected only by a certain point instead of being affected by several different points. For this reason, it is of great importance that the design steps are designed as independently and discretely as possible from each other. Disasters are negative natural events or man-made disasters that can affect many countries in the world. In other words, they are events that cause great loss of human life, destruction of natural environment, private property and public infrastructure. In almost many countries, a state of disaster can occur depending on the geography they are in. While America is struggling with the problems caused by hurricanes, Japan is an earthquake country. The frequent occurrence of these natural disasters in these countries has made them more prepared than others. However, although the type of natural disasters that occur from country to country varies, the relief logistics operations planned to reach and help the disaster victims afterward show great similarity (Adiguzel, 2019).

Relief logistics, which can be evaluated within disaster logistics, deals with the immediate delivery of aid materials to disaster victims and is the subject of this study. Apart from this subject, disaster logistics is related to many issues such as planning rescue activities, recycling of disaster wastes and positioning disaster relief points. relief logistics operations are vital operations that include all dimensions of classical logistics. The effective planning of these operations in a way that ensures integrity will increase the benefit. When the current situation of relief logistics is analyzed, it has been seen that there are processes that cause waste, that it contains operations that are contrary to the nature of classical logistics, and that it includes process steps that are very difficult to carry out in the event of a disaster in practically. For this reason, in order to ensure the flow of operations in relief logistics and to avoid unnecessary steps, an axiom of independence study has been carried out by considering the lean disaster logistics system design. In relief logistics operation design, lean logistics methods such as cross-dock and milk-run transportation were used. The design structure of relief logistics has been prepared in accordance with the dimensions of classical logistics. These dimensions are inbound, outbound and in-plant logistics, and the design steps created according to this structure have been interpreted from a lean perspective, and a design structure that is as lean as possible, as discrete as possible and as appropriate to the nature of relief aid logistics as possible has been created.

2. Axiomatic Design and Independence Axiom

It is a design method that was created by Professor Nam Pyo Suh in the early 90s with the aim of training designers. It contains various axioms and theorems; especially in the last decade, it has been widely used as a tool in software, organization, system, material, manufacturing and process designs. Suh (1990) stated that design includes three main areas, namely manufacturing process design, product design, and organizational design, but that AD has the potential to allow its use in all areas of design. Although the traditional manufacturing approach of "Design-Build-Sell" has been accepted in many sectors for years, it has some permanent problems. In the first of these, 70% of the cost of developing goods/services is spent at the design stage and improvement efforts are useless. Secondly, the traditional approach works well when large-scale productions are made, and cannot respond quickly in today's dynamic and

competitive conditions. Finally, focusing on a single product or a few products rather than product families risks getting the wrong idea about customer requirements, which will lead to economic losses. As a result, the design that meets customer requirements is of great importance. Today, most of companies use traditional marketing methods to get to know the customer (Kurniawan et al., 2004).

2. 1. Purpose of Axiomatic Design

The purpose of axiomatic design is to establish a scientific basis for the design topic and to advance design activities by making the designer use logical thought processes and tools (Kulak et al., 2005). In his axiomatic design studies, Suh focused on decision making during the design process (Tate and Nordlund, 1996). Design with axioms provides the thinking process of creating a new design or developing an existing design (Hirani and Suh, 2005). In short, axiomatic design draws the framework of a good design (Yi and Park, 2005). A successful design starts with what it wants to achieve and continues with how it will be achieved, as shown in Figure 1 (Suh, 1990).

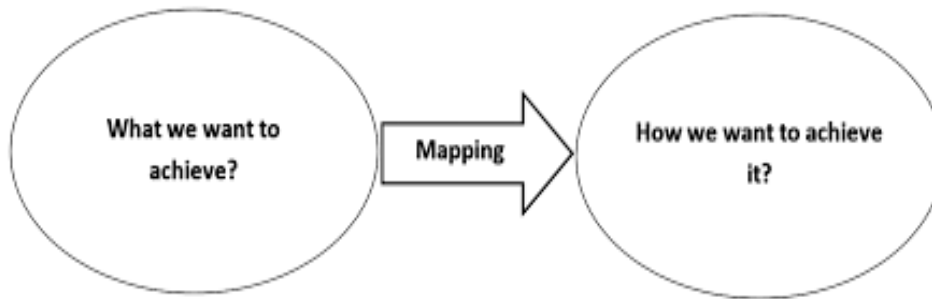


Figure 1. The basic operation of axiomatic design

The most important advantage of axiomatic design over other design methods is that it simplifies the design problems and thus facilitates the solution (Houshmand and Jamshidnezhad, 2005). According to Suh, the most important advantage of axiomatic design over QFD and TRIZ is that it is effective not only in the development of the existing product but also in the development of creative-innovative products. Accordingly, Suh thinks that other methods are more suitable for the development of existing products (Suh, 1990).

2. 2. Axiomatic Design Terms

Axiom: Fundamental truths with no counterexamples or exceptions that are always valid and observed. Axioms are hypothesized by multiple observations of events; cannot be derived or proved, but can be invalidated by counterexamples or exceptions.

Theorem: Propositions that cannot be proved by themselves, but can be proved by accepted axioms. Therefore, a theorem is equivalent to a rule or principle. A theorem is valid if the axiom that gave rise to the theorem is valid.

Conclusions: Proposals that follow axioms or other proven suggestions. The results are either valid or not within the same logic.

Functional Requirements (FR): It is defined as the minimum sum of independent requirements that define all the requirements of the relevant design in the functional knowledge domain. By definition, each FR is independent of other FR's.

Design Parameter (DP): These are the key variables that are defined by the FR, created by the design processes, and characterize by the physical concept (Suh, 1990).

2. 3. FR's of Design

Demands for a product or process are reduced to an independent set of requirements. FR's and independence terms have a special place in the axiom design approach. FR's are the smallest set of independent requirements created for customer requests that determine the design intent. By definition, each FR is independent of other FR's.

FR's specify "What we want to achieve through Design", while DP's specify "How we can achieve FR's". It is very important to determine the FR objectively in the design approach with axioms. The best method for neutrally defining these requirements is a "neutral environment". If impartiality is not achieved, the newly defined set of FR's either have the solutions in the mind of the designer or the characteristics of the existing system (Suh, 1990).

2. 4. Information Fields and Mapping

During the design process, the problem in question can be divided into four knowledge domains. Although the number of knowledge areas is limited to four, the structure of design elements in each knowledge area varies

depending on the problem area (Suh, 1995). knowledge fields; customer information area, physical information area, functional information area and process information area. Each knowledge domain includes different design elements. Respectively; customer requirements (CAs-Customer Appetite), FR's, DP's and process variables (PVs-Process Variables) are an element of the relevant knowledge field. The information field structure is shown in the figure. A design consists of 4 knowledge areas indicated in Figure 2. "What do we want to achieve?" for the field that follows on the left here; the field on the right describes the "How" of meeting the requirements determined by the preceding field. This way of going from "What" to "How" is called "mapping".

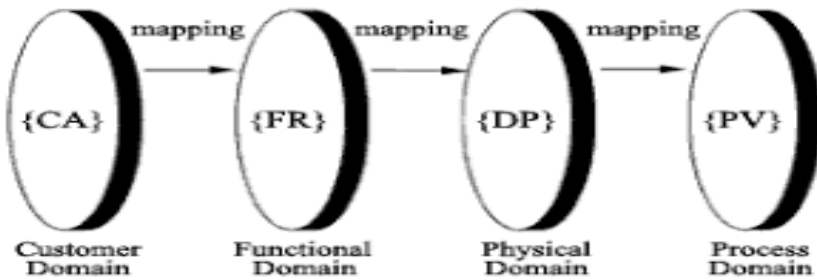


Figure 2. Product development domain model in axiomatic design

2. 5. Decomposition and Zigzagging in Axiomatic Design

The event of progress through the design process (from system to subsystems, assemblies, parts, features of parts) with more detail from top to bottom levels is called the design hierarchy. According to the purpose of the design, there is a hierarchy of functional, physical and process in each knowledge field. There has to be harmony between each level of the functional, physical and process hierarchies. A complete functional hierarchy tree cannot be constructed without a physical hierarchy tree. Likewise, a physical hierarchy tree cannot be constructed without a functional hierarchy tree (Suh, 1997). A designer should make use of the functional and physical hierarchy tree. By eliminating secondary factors, a good designer can identify the most important FR's at each level of the hierarchy tree. As the number of FR's considered increases, so does the complexity of the design process. Therefore, after the set of FR's has been determined at a certain level of the hierarchy, the designer has to move into the physical knowledge domain and set up the physical system that meets the set of FR's. The designer then returns to the functional knowledge area and establishes the lower functional set of requirements. In this way, the designer zigzags through the knowledge fields throughout the process, decomposing the design problem to the point where the solution for the subproblems is known (Figure 3) (Suh, 2001).

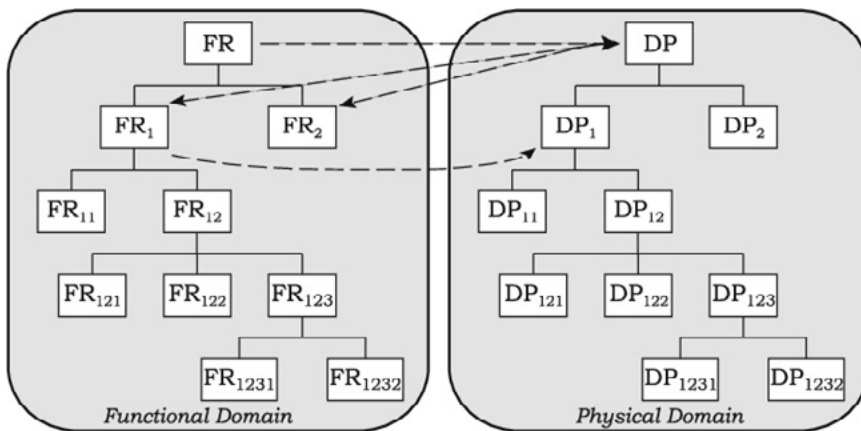


Figure 3. Decomposition and Zigzagging in Axiomatic Design

2. 6. Axioms of Axiomatic Design

Axiomatic design includes 2 axioms. Axiom 1 deals with the relationship between functional and physical variables. Axiom 2, on the other hand, deals with the complexity of the design. These axioms are expressed as (Suh, 1990);

Axiom 1: Independence Axiom: Ensure or maximize independence between FR's. It is the set of the fewest independent requirements that characterize (represent) the objectives of the design (Aydin, 2020). It involves associating DP's with FR's without affecting other FR's (El-Haik and Yang, 1999). The path to be followed during the zigzag process from the FR's in the functional information field to the DP's in the physical information field during the design process is that a certain change in the DP only affects the corresponding FR. Today, engineers frequently use

the method of dividing them into smaller problems and mapping them independently to solve complex problems (Kurniawan et al., 2004).

Axiom 2: Information Axiom: Minimize the information content of the design. Choose the solution with the highest probability of success among the designs. Information content is a measure of complexity (Dukkanci et al., 2023). The design with the least information content is the best design. It enables decision making in a situation where several designs are available for the design in question (Suh, 2001).

2. 7. Results of the Axiomatic Design

Many conclusions can be drawn directly from the 2 axioms of design. These results can be more useful in making specific design decisions, as they can be applied more easily than the axioms themselves in real situations. All of the results are derived from the two basic axioms mentioned and may be called design rules (Suh, 1990).

Result 1 Conversion of linked design to detached design: If the FR's of a proposed design are not independent, achieve functional independence with a decoupled design.

Result 2 Minimization of FR's: Minimize the number of FR's and constraints. For example, use the minimum number of steps in each process.

Result 3 Combining physical parts: If the FR's can be met independently in the proposed solution, combine the features of the design into a single physical part.

Result 4 Use of standardization: If the parts are compatible with FR's and constraints, use those parts that are standard and interchangeable.

Result 5 Use of symmetry: If symmetrical shapes and/or arrangements are compatible with FR's and constraints, use them. For example, make right-hand and left-hand parts together, then distinguish them.

Result 6 Widest tolerance: Decide on the widest possible tolerance for the identified FR's. Reduce costs by using the widest possible tolerances on the parts.

Result 7 Discrete design with less information: Where FR's can be met, seek discrete design where less information is required and choose that design over connected design.

Figure 4 shows the relationships between the above results and the stated axioms. Conclusion 1 is the direct consequence of axiom 1. Results 3, 6, and 7 are derived from axioms 1 and 2. Results 2, 4, and 5 are derived from axiom 2. The meaning of some of these results is seen. But some of them have deeper meanings than they seem. In addition to these results, many conclusions can be drawn. Each proposition derived from the preceding axiom and conclusion is also a conclusion.

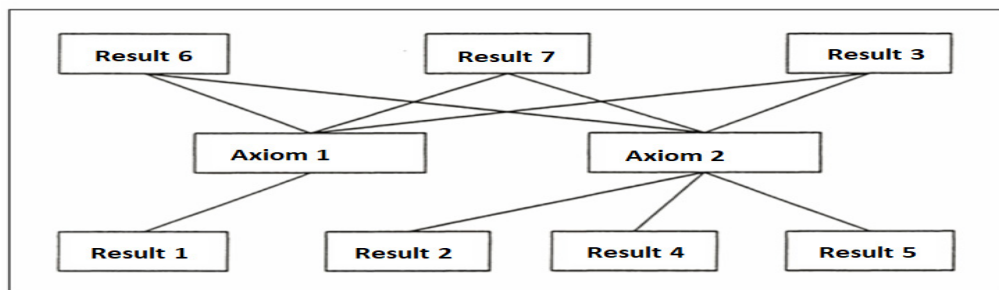


Figure 4. Relationship of results to axioms

2. 8. Design Theorems

Theorems are propositions that cannot be proved by themselves but can be proved by accepted axioms. Therefore, a theorem is equivalent to a rule or principle. A theorem is valid if the axiom that gave rise to the theorem is valid. Theorems created in this context are as follows (Suh, 1990);

Theorem 1 Connected design due to the insufficient number of DP's: When the number of DP's is less than the number of FR's, the solution design either results in a connected design or fails to meet its FR's.

Theorem 2 Converting a connected design to a separated design: If a design is connected because the number of FR's is greater than the number of DP's ($m > n$); this design can be converted to a reserved design by adding a new DP so that the number of FR's of the design is equal to the number of DP's. The design matrix subset contains $m \times n$ elements to form a triangular matrix.

Theorem 3 Redundancy design: When there are DP's greater than the number of FR's, the design is either a redundant design or a dependent design.

Theorem 4 Ideal design: In ideal design, the number of DP's is equal to the number of FR's.

Theorem 5 A new design: When an existing set of FR's is changed by adding a new FR, replacing an existing FR with an existing one, or choosing a completely different set of FR's, the design solution given by the initial DP's creates new FR's. cannot meet the set. Therefore, a new design solution must be sought.

Theorem 6 Path independence of discrete design: The information content of discrete design is independent of the order in which DP's are modified to meet the current set of FR's.

Theorem 7 Path dependence of connected and disconnected designs: The information content of connected and disconnected designs is dependent on the order in which the DP's are changed and the paths specified in the change of these DP's.

2. 9. Design Matrix (DM)

According to Suh, a design will satisfy the axiom of independence only if it is discrete or separated, so it will be static and controllable. Discrete designs are the best designs. It is impossible to separate linked designs into their subcomponents. Because the smallest changes in DP's will lead to variability and uncontrollability. As a result, dependency will reveal that the DP's determined to meet a previous requirement is incorrect or insufficient, and the same requirement will be tried to be met again in a different parameter. Confusion is eliminated by converting connected designs to separated designs (Durmuşoğlu and Kulak, 2004). The relationship between FR's and DP's is defined mathematically by equation (7). This equation is called the design equation.

$$\{FR\} = [DM]\{DP\} \quad (1)$$

If written in more detail,

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ \vdots \\ FR_i \end{Bmatrix} = \begin{bmatrix} DM_{11} & DM_{12} & \dots & DM_{1j} \\ DM_{21} & DM_{22} & \dots & DM_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ DM_{i1} & DM_{i2} & \dots & DM_{ij} \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ \vdots \\ DP_j \end{Bmatrix} \quad (2)$$

Each DM_{ij} element in the DM represents the relationship between the *i*th element of the FR vector and the *j*th element of the DP vector.

$$\{dFR\} = [DM] \{dDP\}$$

From here, the elements of the DM can be written as:

$$DM_{ij} = \partial FR_i / \partial DP_j$$

The DM is discrete (uncoupled, non-diagonal elements of the matrix are zero), separated (triangular, decoupled or quasi-coupled, elements above the diagonal elements of the matrix are zero) or connected (coupled, matrix with non-zero non-zero elements on the top diagonal) Its structure defines the type of design (Sheikholeslami and Zarrinpoor, 2023). Equations 3, 4 and 5 show these structures.

$$\text{Connected Design} \quad \begin{Bmatrix} FR1 \\ FR2 \\ FR3 \end{Bmatrix} = \begin{Bmatrix} X & X & X \\ X & X & X \\ X & X & X \end{Bmatrix} \times \begin{Bmatrix} DP1 \\ DP2 \\ DP3 \end{Bmatrix} \quad (3)$$

$$\text{Non Connected Design} \quad \begin{Bmatrix} FR1 \\ FR2 \\ FR3 \end{Bmatrix} = \begin{Bmatrix} X & 0 & 0 \\ X & X & 0 \\ X & X & X \end{Bmatrix} \times \begin{Bmatrix} DP1 \\ DP2 \\ DP3 \end{Bmatrix} \quad (4)$$

$$\text{Discrete Design} \quad \begin{Bmatrix} FR1 \\ FR2 \\ FR3 \end{Bmatrix} = \begin{Bmatrix} X & 0 & 0 \\ 0 & X & 0 \\ 0 & 0 & X \end{Bmatrix} \times \begin{Bmatrix} DP1 \\ DP2 \\ DP3 \end{Bmatrix} \quad (5)$$

The relationship between the physical space and the process space can be written similarly:

$$\{DP\} = [PDM]\{PV\} \quad (6)$$

3. Relief Logistics System Design via AD

In this study, a study was conducted on the collection of physical aid materials, their temporary storage, their delivery to aid distribution points in disaster areas and their delivery to disaster victims from these points. In our study, independence axiom and lean logistics techniques from axiomatic design approaches were used. Since disaster logistics operations are vital operations, attention has been paid to ensure that the design steps are as independent as possible. A total of 4 design levels were created, from the top design step to the bottom design step. The design steps from the highest level to the lowest level are given under this section. Relevant design steps (FR), how to perform these steps (DP) and sub-design steps (FRi) are included under the relevant headings towards the lower levels. In this section, it is aimed to create a holistic roadmap for the flow of relief logistics with the help of axiomatic design principles. The roadmap consists of seven stages (Kabadurmuş ve Durmuşoğlu, 2005).

Stage 1. Identify Barriers to Flow in Relief Logistics: Before deciding what to do, it should be well understood why change will be necessary. The earthquakes that took place on February 6, 2023 showed that there is no work flow to be followed regarding the planning of post-disaster aid and delivery to the disaster victims. For this reason, there is a requirement for a workflow that will guide the authorities in order to deliver the aid to the disaster victims smoothly and quickly.

Stage 2. Identification of FR's for the Functional Knowledge Area: The next step after determining what is required for the smooth delivery of aid to the victims is to identify the highest hierarchical FR that corresponds to this requirement. From an axiomatic design point of view, there can be very different designs on the same subject. The FR selected in the highest hierarchy can lead the designer to different designs. The highest FR must therefore be chosen very carefully and logically. The FR chosen in the considered design is given below:

FR = Streamline relief logistics

In order to design disaster logistics operations in a way that ensures flow, the highest level of FR has been determined in this way.

Stage 3. Establishing the DP from FR's by Mapping: With the mapping process to be made between the functional information field and the physical information field, the DP's corresponding to the FR's are determined. In the design process, responding to FR's with the right DP's is as important as defining the right FR's. The DP's corresponding to the highest FR was chosen as follows:

DP = Lean relief logistics system design

The key to ensuring smooth flow in disaster logistics is the lean disaster logistics system design. It will be possible to provide flow by structuring disaster logistics operations with a lean logistics perspective.

Stage 4. Detailed Analysis of the Functional Knowledge Area – Zigzag Decomposition of FR's: Suh (1990) states that if the selected DP's are not clear enough to be fully understood or applied, the designer should return to the functional knowledge area and continue to decompose the design. Therefore, the first parsing was done as follows:

FR 1 = Set up the physical aid admission system

FR 2 = Stream in required warehouses for physical assistance

FR 3 = Create physical aid distribution planning

Stage 5. Finding the DP for Each FR by Mapping: To meet the FR 1, FR 2 and FR 3 described in Stage 4, the appropriate DP's should be selected by going back to the physical information field.

The sub-steps of providing flow in disaster logistics from a lean logistics perspective are to apply them in each sub-operation step. As can be understood from the above four FR parameters, the process of delivering physical aids to the victims consists of the collection of physical aid materials, the short-term storage of these materials before dispatch, the transportation of the aid materials to the disaster areas, the aid distribution points located in the disaster areas and the delivery of these aids to the disaster victims. The DP's corresponding to each design step and showing how this design step can be achieved are as follows.

DP 1 = The designed aid collection systematic

DP 2 = The designed cross-dock systematic

DP 3 = Designed logistics mix structures

These decomposition processes described are summarized in Equation 7.

Stage 6. Creating the DM: As emphasized earlier, there are axioms in design methodology with axioms that the designer must abide by. First, the axiom of independence requires independence between FR's. This means that the DM is discrete, or at least split design. The DM of the design presented with the first decomposition is as in Figure 1.

$$\begin{bmatrix} FR1 \\ FR2 \\ FR3 \end{bmatrix} = \begin{bmatrix} X & & \\ & X & \\ & & X \end{bmatrix} \begin{bmatrix} DP1 \\ DP2 \\ DP3 \end{bmatrix} \quad (7)$$

Figure 1 shows the decomposition of FR. As can be seen, the design is discretized.

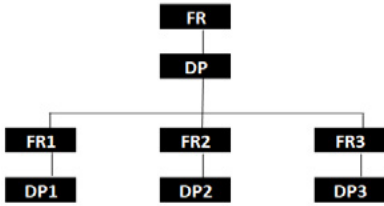


Figure 1. Decomposition of FR

3. 1. Setting Up The Physical Aid Admission System Policy

This step, which is the stage of collecting or accepting physical aid materials, corresponds to the “Inbound Logistics” dimension from the logistics dimensions. At this stage, there are sub-design steps according to the collection of aid acceptance materials from addresses or the arrival of aid recipients with their vehicles, the acceptance of aid materials to the facility and the withdrawal of the accepted materials to the short-term storage area. The FR's mentioned are collected as follows.

FR 11 = Organize materials to be collected from addresses

FR 12 = Direct aid recipients to the aid reception area

FR 13 = Determine the number of aid-accepting staff

FR 14 = Transfer received relief items to cross-dock area

The DP's corresponding to the above FR's are as follows.

DP 11 = Designed milk-run operations

DP 12 = Systematic redirection to the aid acceptance area

DP 13 = Work and workload analysis for aid acceptance

DP 14 = Work and workload analysis for aid transfer

The DM for the resulting decomposition can be represented as:

$$\begin{bmatrix} FR11 \\ FR12 \\ FR13 \\ FR14 \end{bmatrix} = \begin{bmatrix} X & & & \\ & X & & \\ & & X & \\ & & & X \end{bmatrix} \begin{bmatrix} DP11 \\ DP12 \\ DP13 \\ DP14 \end{bmatrix} \quad (8)$$

Figure 2 shows the decomposition of FR 1. As can be seen, the design is discretized.

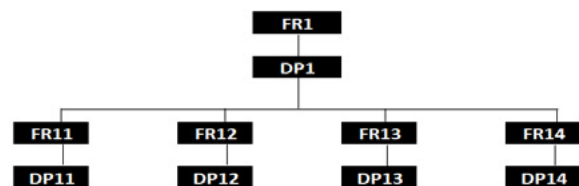


Figure 2. Decomposition of FR 1

In this step, which is related to the collection of physical aid materials from addresses; includes the sub-steps of obtaining address information, determining the type and number of vehicles that will be required, and collecting vehicles and aid materials from addresses. The mentioned FR's are collected as follows.

FR 111 = Get help with material volume and address information

FR 112 = Calculate required vehicle types and numbers

FR 113 = Provide vehicle organization for the collection of relief materials

The DP's corresponding to the above FR's are as follows.

DP 111 = Designed call center operations

DP 112 = Calculation of declared aid volumes and vehicle capacities

DP 113 = Inbound logistics operations configured by milk-run

The DM for the resulting decomposition can be represented as follows:

$$\begin{bmatrix} FR111 \\ FR112 \\ FR113 \end{bmatrix} = \begin{bmatrix} X & & \\ & X & \\ X & & X \end{bmatrix} \begin{bmatrix} DP111 \\ DP112 \\ DP113 \end{bmatrix} \quad (9)$$

Figure 3 shows the parsing of FR 11. As can be seen, the design is a separated design and conforms to the independence axiom. Call center operations also affect vehicle organization.

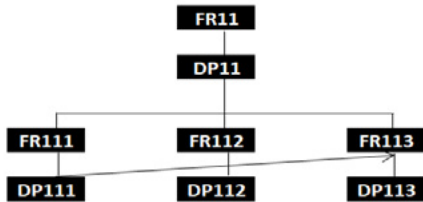


Figure 3. Decomposition of FR 11

Received relief items must be properly transferred to the cross-dock area for short-term storage. This step covers the steps of organizing personnel training and placing the trained personnel in appropriate operations in order to ensure the provision of appropriate and sufficient personnel. These sub-steps also serve FR 21, FR 22 and FR 24 designs. The mentioned FR's are collected as follows.

FR 141 = Organize staff training

FR 142 = Place trained personnel in appropriate operations

The DP's corresponding to the above FR's are as follows.

DP 141 = Updated training planning

DP 142 = Personnel assignment process workflow

The DM for the resulting decomposition can be represented as follows:

$$\begin{bmatrix} FR141 \\ FR142 \end{bmatrix} = \begin{bmatrix} X & \\ X & X \end{bmatrix} \begin{bmatrix} DP141 \\ DP142 \end{bmatrix} \quad (10)$$

Figure 4 shows the decomposition of FR 14. As can be seen, the design is separated and conforms to the independence axiom. Updated training planning influences the placement of trained personnel into the appropriate operation.

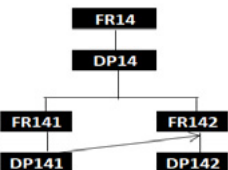


Figure 4. Decomposition of FR 14

3. 2. Providing Required Flow in Warehouses For Physical Aid Policy

This step corresponds to the "In-Plant Logistics" stage, one of the dimensions of logistics. At this stage, the sorting process, which includes the sorting of the materials arriving in the cross-dock area according to their types, the operations of arranging the sorted materials on empty pallets, the prioritization of the physical aid materials placed on the pallets according to the requirements of the victims, and the transfer of the aid materials placed on the pallets to the loading stage are included. The mentioned FR's are collected as follows.

FR 21 = Sort materials in the cross-dock area

FR 22 = Arrange sorted materials on pallets

FR 23 = Provide requirements prioritization of physical aid supplies

FR 24 = Transfer palletized materials to the loading area

The DP's corresponding to the above FR's are as follows.

DP 21 = Sorting workflow and workload analysis

DP 22 = Palletizing workflow and workload analysis

DP 23 = Current requirements lists from authorized aid organizations

DP 24 = Workload analysis for transfer

The DM for the resulting decomposition can be represented as follows:

$$\begin{bmatrix} FR21 \\ FR22 \\ FR23 \\ FR24 \end{bmatrix} = \begin{bmatrix} X & & & \\ & X & & \\ & & X & \\ & & & X \end{bmatrix} \begin{bmatrix} DP21 \\ DP22 \\ DP23 \\ DP24 \end{bmatrix} \quad (11)$$

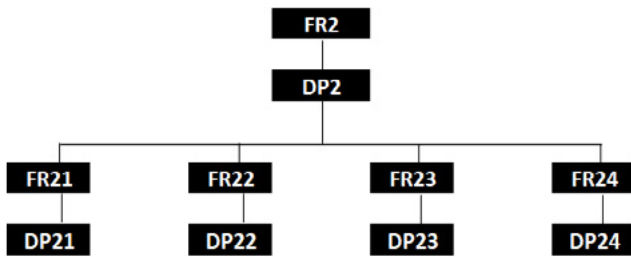


Figure 5. Decomposition of FR 2

Figure 5 shows the decomposition of FR 2. As can be seen, the design is discrete and conforms to the independence axiom.

3. 3. Creating Physical Aid Distribution Planning Policy

This step corresponds to the “Outbound Logistics” step, which is one of the dimensions of logistics. At this stage, the logistics mix components (such as logistics mode, logistics vehicle, logistics route, insurance operations, and logistics documentation), prioritizing the materials to be loaded on the vehicles and delivering the aid materials constitute the sub-design steps. The mentioned FR's are collected as follows.

FR 31 = Determine the correct logistics mode

FR 32 = Determine logistics vehicles in accordance with the logistics mode

FR 33 = Load materials into vehicles prioritizing

FR 34 = Determine logistics routes

FR 35 = Analyze loading fees and insurance transactions

FR 36 = Determine logistics documentation and processes

FR 37 = Deliver relief materials

The DP's corresponding to the above FR's are as follows.

DP 31 = Revised logistics mode

DP 32 = Revised logistics tools

DP 33 = The updated victim requirements lists

DP 34 = Outbound logistics operations configured with milk-run method

DP 35 = Expedition costs – aid organizations comparison

DP 36 = Established workflow for documentation and processes

DP 37 = Authorized aid organizations

The DM for the resulting decomposition can be represented as follows:

$$\begin{bmatrix} FR31 \\ FR32 \\ FR33 \\ FR34 \\ FR35 \\ FR36 \\ FR37 \end{bmatrix} = \begin{bmatrix} X & & & & & & \\ & X & & & & & \\ & & X & & & & \\ & & 0 & X & & & \\ & & 0 & 0 & X & & \\ & & 0 & 0 & 0 & X & \\ & & 0 & 0 & 0 & & X \end{bmatrix} \begin{bmatrix} DP31 \\ DP32 \\ DP33 \\ DP34 \\ DP35 \\ DP36 \\ DP37 \end{bmatrix} \quad (12)$$

Figure 6 shows the decomposition of FR 3. As can be seen, the design is discrete and conforms to the independence axiom.

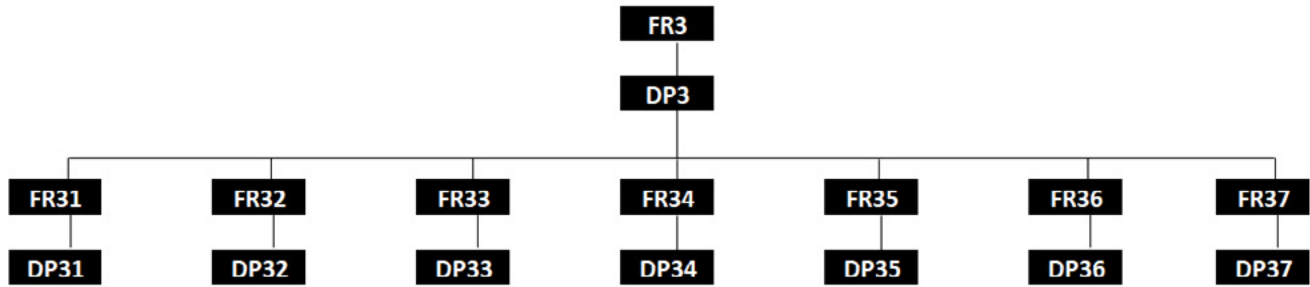


Figure 6. Decomposition of FR 3

After deciding on the relevant logistics mode or modes, in this step consists of the sub-steps of determining the type and number of vehicles requirement to determine the vehicles suitable for this mode or modes, sharing this information with private and public institutions, and evaluating the suitability of the vehicles for loading. The mentioned FR's are collected as follows.

FR 321 = Calculate the type and number of vehicles required by the loading points

FR 322 = Share the required number of vehicles with private and public institutions

FR 323 = Evaluate the suitability of incoming vehicles for loading

The DP's corresponding to the above FR's are as follows.

DP 321 = Comparison of aid volumes at loading points with vehicle volumes

DP 322 = Determined aid request announcement regulation

DP 323 = Determined vehicle control process regulation

The DM for the resulting decomposition can be represented as follows:

$$\begin{bmatrix} FR321 \\ FR322 \\ FR323 \end{bmatrix} = \begin{bmatrix} X & & \\ & X & \\ & & X \end{bmatrix} \begin{bmatrix} DP321 \\ DP322 \\ DP323 \end{bmatrix} \quad (13)$$

Figure 7 shows the decomposition of FR 32. As can be seen, the design is discrete and conforms to the independence axiom

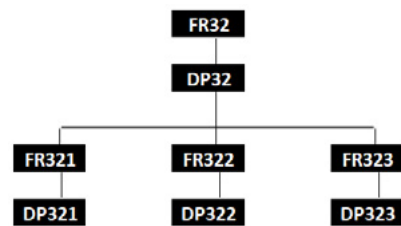


Figure 7. Decomposition of FR 32

In "prioritizing materials into vehicles" stage includes the steps of obtaining and prioritizing the victim's requirements lists, prioritizing the materials in the loading area accordingly, and prioritizing the vehicles to be loaded accordingly, in order to perform the prioritization processes correctly. The mentioned FR's are collected as follows.

FR 331 = Obtain and prioritize disaster victim requirements lists

FR 332 = Prioritize materials in the loading area

FR 333 = Prioritize vehicles to be loaded

The DP's corresponding to the above FR's are as follows.

DP 331 = Current requirements lists by region

DP 332 = Help area – loading organization communication network

DP 333 = Vehicle drivers – load organization communication network

The DM for the resulting decomposition can be represented as follows:

$$\begin{bmatrix} FR331 \\ FR332 \\ FR333 \end{bmatrix} = \begin{bmatrix} X & & \\ X & X & \\ X & & X \end{bmatrix} \begin{bmatrix} DP331 \\ DP332 \\ DP333 \end{bmatrix} \quad (14)$$

Figure 8 shows the decomposition of FR 33. As can be seen, the design is a separated design and conforms to the independence axiom. The design is a segregated design rather than a discrete one, as the current requirement lists on a regional basis affect all prioritization processes.

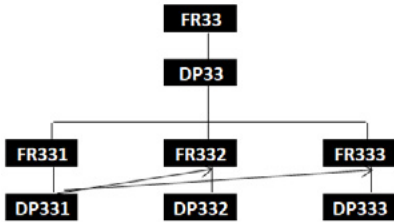


Figure 8. Decomposition of FR 33

In this step consists of making use of route optimization software in order to achieve route optimization, determining the appropriate software company and assigning the personnel to use the software. The mentioned FR's are collected as follows.

FR 341 = Utilize route optimization software

FR 342 = Determine the appropriate software company

FR 343 = Assign a user for route optimization software

The DP's corresponding to the above FR's are as follows.

DP 341 = Updated route optimization software company list

DP 342 = Regulation on receiving services in disaster situations

DP 343 = Route optimization training process workflow

The DM for the resulting decomposition can be represented as follows:

$$\begin{bmatrix} FR341 \\ FR342 \\ FR343 \end{bmatrix} = \begin{bmatrix} X & & \\ & X & \\ & & X \end{bmatrix} \begin{bmatrix} DP341 \\ DP342 \\ DP343 \end{bmatrix} \quad (15)$$

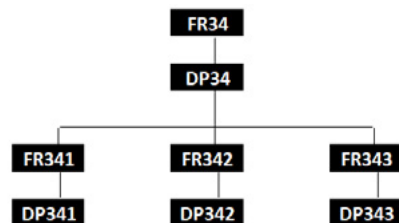
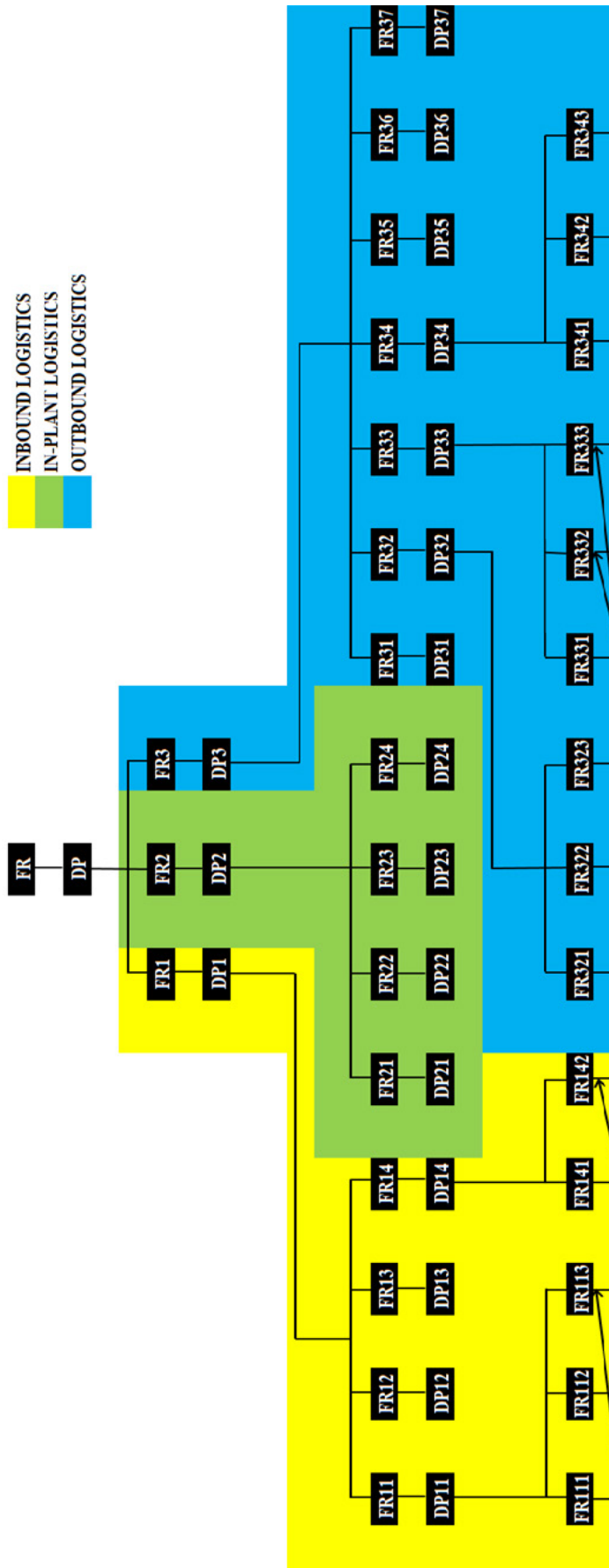


Figure 9. Decomposition of FR 34

Figure 9 shows the decomposition of FR 34. As can be seen, the design is a discrete and conforms to the independence axiom.



Design Matrix for FR 1 and FR 2			DP 1 = The designed aid collection systematic										DP 2 = The designed cross dock					
			DP 11 = Designed milk-run operations				DP 11			DP 12 = Systematic redirection to the aid acceptance area	DP 13 = Work and workload analysis for aid acceptance	DP 14 = Work and workload analysis for aid transfer	DP 14		DP 21 = Sorting workflow and workload analysis	DP 22 = Palletizing workflow and workload analysis	DP 23 = Current requirements lists from authorized aid organizations	DP 24 = Workload analysis for transfer
							DP 111 = Designed call center operations	DP 112 = Calculation of declared aid volumes and vehicle capacities	DP 113 = Inbound logistics operations configured by milk-run									
FR 1 = Set up the physical aid admission system	FR 11 = Organize materials to be collected from addresses	FR 111 = Get help with material volume and address information																
		FR 112 = Calculate required vehicle types and numbers		X														
		FR 113 = Provide vehicle organization for the collection of relief materials	X		X													
			FR 12 = Direct aid recipients to the aid reception area					X		X								
FR 2 = Stream in required warehouses for physical assistance	FR 14 = Transfer received relief items to cross dock area	FR 13 = Determine the number of aid-accepting staff																
		FR 141 = Organize staff training										X						
		FR 142 = Place trained personnel in appropriate operations											X					
			FR 21 = Sort materials in the cross dock area												X			
		FR 22 = Arrange sorted materials on pallets													X			
		FR 23 = Provide requirements prioritization of physical aid supplies														X		
		FR 24 = Transfer palletized materials to the loading area																X

Table 1. Complete DM for relief logistics system design (FR 1 and FR 2)

Design Matrix for FR 3		DP 3 = Designed logistics mix structures																		
		DP 31 = Revised logistics mode		DP 32 = Revised logistics tools	DP 32				DP 33 = The updated victim requirements lists	DP 33				DP 34				DP 35 = Expedition costs – aid organizations comparison	DP 36 = Established workflow for documentation and processes	DP 37 = Authorized aid organizations
FR 3 = Create physical aid distribution planning	FR 31 = Determine the correct logistics mode	X																		
	FR 32 = Determine the logistics mode	FR 321 = Comparison of aid volumes at loading points with vehicle																		
		DP 322 = Determined aid request announcement regulation																		
		DP 323 = Determined vehicle control process regulation																		
		DP 33 = The updated victim requirements lists																		
		DP 331 = Current requirements lists by loading organization																		
		DP 332 = Help area – communication network																		
FR 33 = Load materials into vehicles	FR 331 = Obtain and prioritize disaster victim requirements lists																			
	FR 332 = Prioritize materials in the loading area																			
	FR 333 = Prioritize vehicles to be loaded																			
	FR 34 = Determine logistics routes																			
FR 35 = Analyze loading fees and insurance transactions	FR 341 = Utilize route optimization software																			
	FR 342 = Determine the appropriate software company																			
	FR 343 = Assign a user for route optimization software																			
FR 36 = Determine logistics documentation and processes	FR 35 = Analyze loading fees and insurance transactions																			
	FR 36 = Determine logistics documentation and processes																			
	FR 37 = Deliver relief materials																			

Table 2. Complete DM for relief logistics system design (FR 3)

During the creation of DP's, the current relief logistics literature for 2014 - 2024 was examined. By examining the literature in question in depth and detail, 29 DP's were created and 27 scientific studies were used for these parameters. Thus, the validity of the design is strongly supported by current literature. The study conducted is presented in Table 3.

When the relevant table is examined, it will be seen that some DP's are related to more than one scientific study. This indicates that relevant studies were used to create the DP in question. Likewise, it will be seen that some scientific studies are related to more than one DP. This indicates that the scientific study in question played a role in the creation of more than one DP.

When the frequency values in the table are examined, the scientific studies that contribute the most to the creation of the design will be seen. Likewise, care was taken to ensure that each DP was examined by at least one study. Of the total 29 DP's, 12 were examined by 1 study, 8 by 2 studies, and 9 by 3 or more scientific studies.

	DESIGN PARAMETERS (DP's)																																	
	DP 11	DP 111	DP 112	DP 113	DP 12	DP 13	DP 14	DP 141	DP 142	DP 21	DP 22	DP 23	DP 24	DP 31	DP 32	DP 321	DP 322	DP 323	DP 33	DP 331	DP 332	DP 333	DP 34	DP 341	DP 342	DP 343	DP 35	DP 36	DP 37	Frequency				
SCIENTIFIC STUDIES	Sheu (2014)																									X					1			
	Bozorgi-Amiri and Asvadi (2015)																									X					1			
	Loree and Aros-Vera (2018)										X																X				2			
	Moreno et al. (2018)																										X				1			
	Noyan ve Kahvecioglu (2018)																									X					1			
	Yu et al. (2018)																										X				1			
	Henrique de Moura et al. (2020)																												X		1			
	Sabbaghtorkan et al. (2020)																													X	1			
	Yilmaz and Kabak (2020)										X											X									2			
	Goerlandt and Islam (2021)																				X										1			
	Yanez-Sandivari et al. (2021)														X														X	X	3			
	Ertem et al. (2022)												X						X													4		
	Ghelichi et al. (2022)						X	X						X																		3		
	Kim et al. (2022)								X																							1		
	Mehrjerdi and Karimi (2022)								X																							2		
	Timperio et al. (2022)	X			X								X							X	X			X						X	X	7		
	Dukkanci et al. (2023)																		X								X					3		
	Guo and Matsuda (2023)		X																									X				2		
	Kawase and Iryo (2023)					X													X								X		X			4		
	Luo et al. (2023)																		X			X										3		
	Sheikholeslami and Zarrinpoor (2023)		X							X									X										X			4		
	Zhang et al. (2023)											X			X				X	X	X	X							X			9		
Chai et al. (2024)			X														X							X		X	X	X			6			
Chang et al. (2024)																															1			
Korucuk et al. (2024)										X		X							X	X										X	5			
Mota-Santiago and Lozano (2024)																															1			
Rahimi and Rahmani (2024)			X														X							X	X	X	X				6			
Frequency	1	2	2	1	1	1	1	2	1	2	2	4	1	2	1	1	1	5	4	4	3	3	1	2	8	2	11	1	6					

Table 3. DP's – Relief Logistics Literature Relationship Matrix

4. Conclusion

Disasters cause high loss of life because they cause great damage in a very short time without warning in general. Even when the disaster situation is over, people continue to lose their lives both because they are injured and because they are separated from their requirements. The early days following a disaster are vital to rescuing survivors. However, it takes time to understand the severity of the disaster, to gather and organize the necessary aid resources, and to bring these aid resources together with those in requirement correctly, which takes time away from the vital time for the disaster victims.

For this reason, the operation of collecting aid materials, sorting them in warehouses and bringing them together with the disaster victims in disaster logistics is handled as relief logistics in this study and a study that can help the authorities in order to organize this operation smoothly has been put forward. The relief logistics operation covers all dimensions of a general logistics operation. For this reason, the relief logistics operation has been interpreted with a lean logistics perspective and an design structure has been tried to be created that is free from unnecessary, wasteful and non-value-added factors.

Within the scope of the study, a guiding method has been proposed using the axiomatic design method for the lean relief logistics-based system. This study, which makes use of logistics principles and lean logistics storage and transportation methods, is very new since the axiomatic design methodology was used for the first time in relief logistics, and in this respect, it brings innovation to the literature. While the design in question was being put forward, the concept of relief logistics was divided into dimensions, taking into account the structure of classical logistics.

The issue was handled from a lean logistics perspective to ensure that relief materials were delivered to disaster victims on time, accurately, and completely. Relief logistics was restructured by taking into account the dimensions of classical logistics. Thus, the ways and methods applied to classical logistics were adapted to relief logistics and a complete study that could guide the authorities working in this field was presented. Figure 10 presents the general structure of the design. Examining this figure will reveal which design steps correspond to which logistics dimension. Tables 1 and 2 show the DM-FR relationships. For a design as discrete as possible, care was taken to ensure that each DP was not associated with more than one FR. Because we know that a discrete design is crucial for ensuring that each missed DP affects a minimum number of FRs, another unique aspect of this design, developed using the independence axiom methodology, is its use of current literature. Table 3 lists the current literature sources used for each design step. This table shows which current publications are associated with which DM in the design. Twenty-seven closely related publications were utilized in the creation of the 29 DP's.

Suggestions to guide researchers for future studies can be listed as follows. The Axiomatic Design methodology can also be applied to other operations of disaster logistics. A number of disaster logistics operations, such as correct prioritization of rescue activities, transfer of victims to temporary shelters in the correct order, distribution of aid materials delivered to disaster areas, and correct post-disaster transportation of disaster wastes, can be improved with Axiomatic Design methodology. In addition, it will be possible to maximize the benefit by applying the said methodology together with other scientific methodologies used in disaster logistics operations.

Declaration of Interest Statement

The author confirms that there is no known conflict of interest or common interest with any institution/organization or person.

Data Availability Statement

The author confirms that the data shared in this article is ethically sound and does not violate the protection of person or institutions/organization or other valid ethical, privacy and security concerns.

Ethics Committee Approval

Ethics committee approval is not required.

References

- ADIGUZEL, S. (2019) Logistics management in disaster, *Journal of Management, Marketing and Logistics*, 6(4), 212-224.
- ATES, O. (2023) Determination of transport method for in-bound logistics by information axiom and fuzzy information axiom approach, *International Journal of Shipping and Transport Logistics*, 17, 214-231.
- AYDIN, N., Designing reverse logistics network of end-of-life-buildings as preparedness to disasters under uncertainty, *Journal of Cleaner Production*, 256, 2020.

BOZORGI-AMIRI, A. and ASVADI, S. (2015) A prioritization model for locating relief logistic centers using analytic hierarchy process with interval comparison matrix, *Knowledge-Based Systems*, 86, 173-181.

CHAI, R., HE, H., LIU, D. and CHEN J. (2024) A fuzzy multi-objective programming model for the delivery and distribution of humanitarian relief materials, *Engineering Applications of Artificial Intelligence*, 137, 109113.

CHANG, K-H., CHIANG, Y-C. and CHANG, T-Y. (2018) Simultaneous location and vehicle fleet sizing of relief goods distribution centers and vehicle routing for post-disaster logistics, *Computers and Operations Research*, 161, 106404.

DUKKANCI, O., KOBERSTAIN, A. and KARA, B. Y. (2023) Drones for relief logistics under uncertainty after an earthquake, *European Journal of Operational Research*, 310, 117-132.

DURMUSOGLU, M. B. and KULAK, O., Planning and implementation of teamwork based office cells according to axiomatic design principles, *UCLEA Chamber of Mechanical Engineers Journal of Industrial Engineering*, 17(1), 2-28, 2004.

EL-HAIK, B. S. and YANG, K., The components of complexity in engineering design, *IEE Transactions*, 31, 925-934, 1999.

ERTEM, M. A., AKDOGAN, M. A. and KAHYA, M. (2022), Intermodal transportation in humanitarian logistics with an application to a Turkish network using retrospective analysis, *International Journal of Disaster Risk Reduction*, 72, 102828.

GHELICHI, Z., GENTILI, M. and MARCHANDANI, P. B. (2022) Drone logistics for uncertain demand of disaster-impacted populations, *Transportation Research Part C*, 141, 103735.

GOERLANDT, F. and ISLAM, S. (2021) A Bayesian Network risk model for estimating coastal maritime transportation delays following an earthquake in British Columbia, *Reliability Engineering and System Safety*, 214, 107708.

GUO, Y. and MATSUDA, T. (2023) Study on the multi-criteria location decision of wide-area distribution centers in pre-disaster: Case of an earthquake in the Kanto district of Japan, *Asian Transport Studies*, 9, 100107.

HENRIQUE de MOURA, E., ROCHA e CRUZ, T. B. and GENARO CHIROLI, D. M. (2020) A framework proposal to integrate humanitarian logistics practices, disaster management and disaster mutual assistance: A Brazilian case, *Safety Science*, 132, 104965.

HIRANI, H. and SUH, N. P., Journal bearing design using multiobjective genetic algorithm and axiomatic design approaches, *Tribology International*, 38, 481-491, 2005.

HOUSHMAND, M. and JAMSHIDNEZHAD, B., An extended model of design process of lean production systems by means of process variables, *Robotics and Computer Integrated Manufacturing*, 22:1-1, 2005.

KABADURMUS, Ö. and DURMUSOGLU M. B. (2005) Design of pull/kanban production control systems using axiomatic design principles, *UCLEA Chamber of Mechanical Engineers Journal of Industrial Engineering*, 18(2), 2-28.

KAWASE, R. and IRYO, T. (2023) Optimal stochastic inventory-distribution strategy for damaged multi-echelon humanitarian logistics network, *European Journal of Operational Research*, 309, 616-633.

KIM, J. J., JANG, H. and ROH, S. (2022) A systematic literature review on humanitarian logistics using network analysis and topic modeling, *The Asian Journal of Shipping and Logistics*, 38, 263-278.

KORUCUK, S., AYTEKIN A., GORCUN, Ö., SIMIC, V. and GORCUN, Ö. F. (2024) Warehouse site selection for humanitarian relief organizations using an interval-valued fermatean fuzzy LOPCOW-RAFSI model, *Computers & Industrial Engineering*, 192, 110160.

KULAK, O., DURMUSOGLU, M. B. and KAHRAMAN, C., Fuzzy multi-attribute equipment based on information axiom, *Journal of Material Processing Technology*, 169, 337- 345, 2005.

KURNIAWAN, S. H., ZHANG, M. and TSENG, M. M., Connecting customers in axiomatic design, *The 3rd International Conference On Axiomatic Design*, 21-24, 2004.

LOREE, N. and AROS-VERA, F. (2018) Points of distribution location and inventory management model for Post-Disaster Humanitarian Logistics, *Transportation Research Part E*, 116, 1-24.

LUO, J., SHI, L., XUE, R. and EL-BAZ, D. (2023) Optimization models and solving approaches in relief distribution concerning victims' satisfaction: A review, *Applied Soft Computing*, 143, 110398.

MEHRJERDI, Y. Z. and KARIMI S. (2022) System dynamics modeling of relief logistics, *Journal of Engineering Research*, Online First Articles.

MORENO, A., ALEM, D., FERREIRA, D. and CLARK, A. (2018), An effective two-stage stochastic multi-trip location-transportation model with social concerns in relief supply chains, *European Journal of Operational Research*, 269, 1050-1071.

MOTA-SANTIAGO, L. R. and LOZANO, A. (2024) Mathematical problems for designing a short-distance relief goods distribution network in urban areas, *Transportation Research Procedia*, 78, 281-288.

NOYAN, N. and KAHVECIOGLU, G. (2018) Stochastic last mile relief network design with resource reallocation, *OR Spectrum*, 40, 187-231.

RAHIMI, S. K. and RAHMANI, D. (2024) An improved ALNS for hybrid pickup and drones delivery system in disaster by penalizing deprivation time, Computers and Operations Research, 170, 106722.

SABBAGHTORKAN, M., BATTAT, R. and HE, Q. (2020) Prepositioning of assets and supplies in disaster operations management: Review and research gap identification, European Journal of Operational Research, 284, 1-19.

SHEIKHOLESLAMI, M. and ZARRINPOOR, N. (2023) Designing an integrated humanitarian logistics network for the preparedness and response phases under uncertainty, Socio-Economic Planning Sciences, 86, 101496.

SHEU, J-B. (2018) Post-disaster relief-service centralized logistics distribution with survivor resilience maximization, Transportation Research Part B, 68, 288-314.

SUH, N.P. (1990)., The principles of design, Oxford University Press, New York.

SUH, N. P., Design and operation of large systems, Journal of Manufacturing Systems, 14(3), 203-213, 1995.

SUH, N. P., Design of systems, Annals of CIRP, 46(1), 75-80, 1997. Suh, N.P., Axiomatic Design: Advances and Applications, Oxford University Press, New York, 2001.

TATE D. and NORDLUND M., A design process roadmap as a general tool for structuring and supporting design activities, Proceedings of the Second World Conference on Integrated Design and Process Technology, 3, 97- 104, 1996.

TIMPERIO, G., KUNDU, T. KLUMPP, M., SOUZA, R., LOH, X. H. and GOH, K. (2022) Beneficiary-centric decision support framework for enhanced resource coordination in humanitarian logistics: A case study from ASEAN, Transportation Research Part E, 167, 102909.

YANEZ-SANDIVARI, L., CORTES, C. E. and REY, P. A. (2021) Humanitarian logistics and emergencies management: New perspectives to a sociotechnical problem and its optimization approach management, International Journal of Disaster Risk Reduction, 52, 101952.

YI, J. W. and PARK, G. J., Development of a design system for EPS cushioning package of a monitor using axiomatic design, Advances in Engineering Software, 36, 285, 2005.

YILMAZ, H. and KABAK, Ö. (2020) Prioritizing distribution centers in humanitarian logistics using type-2 fuzzy MCDM approach, Journal of Enterprise Information Management, 33(5), 1199-1232.

YU, L., ZHANG, C., Yang, H. and Miao, L. (2018) Novel methods for resource allocation in humanitarian logistics considering human suffering, Computers & Industrial Engineering, 119, 1-20.

ZHANG, D., ZHANG, Y., LI, S. and LI, S. (2023) A novel min-max robust model for post-disaster relief kit assembly and distribution, Expert System with Application, 214, 119198.

Özet

Merkez üssü Kahramanmaraş'ın Pazarcık ilçesi olan, 06.02.2023 saat 04.17'de meydana gelen 7.7 şiddetindeki depremin şoku henüz atlatılmadan aynı bölgede bu sefer Kahramanmaraş'ın Elbistan ilçesinde aynı gün 13.24'de 7.6 şiddetinde başka bir deprem meydana geldi. Deprem Türkiye'de 12 şehri ve Suriye'nin güney şehirlerini etkiledi ve şu ana kadar Türkiye'de 50.783 kişi ve Suriye'de 8.476 kişinin hayatını kaybettiği ve 122.000'den fazla kişinin yaralandığı bildirildi. Meydana gelen bu depremler ve sonrasında yaşanan aksaklıklar, yardım lojistiği operasyonlarının bilinçli bir şekilde ve bir plan doğrultusunda sürdürülmediği sonucu net bir şekilde ortaya çıkmıştır. Bu konudaki otorite sahiplerine yol gösterecek ve yardımların toplanmasından bu yardımların ilgili afetzedelere teslimine kadarki süreçleri içerecek insani yardım lojistiği konusu dâhilinde bir çalışma yapılması gerekli görülmüştür. Metodoloji olarak Aksiyomlarla Tasarım yaklaşımlarından Bağımsızlık Aksiyomu tercih edilmiştir. Bu yöntemin seçilmesinin en büyük nedeni, ideal afet lojistiği operasyonu tasarım adımlarının olabildiğince birbirinden bağımsız olmasının önemini hayati düzeyde olmasıdır.

Aksiyomlarla tasarım Profesör Nam Pyo Suh tarafından 90'lı yılların başında tasarımcı yetiştirebilme amaçlı eğitim organizasyonu ile ortaya çıkarılmış tasarım metodudur. Çeşitli aksiyomlar ve teoremler içermekte olup; özellikle son on yılda yazılım, organizasyon, sistem, malzeme, imalat ve süreç tasarımlarında bir araç olarak yaygın şekilde kullanılmaktadır. Aksiyomlarla tasarımın amacı, tasarım konusu için bilimsel bir temel oluşturmak ve tasarımcıya mantıksal düşünce süreçleri ve araçları kullanarak tasarım aktivitelerini ilerletmektir.

Yayınımızda fiziksel yardım malzemelerinin toplanması, geçici bir süre depolanması, afet bölgelerindeki yardım dağıtım noktalarına ulaştırılması ve bu noktalardan afetzedelere teslim edilmesi ile ilgili yardım lojistiği konulu çalışma yürütülmüştür. Çalışmamızda aksiyomlarla tasarım yaklaşımlarından bağımsızlık aksiyomu ve yalın lojistik taşıma ve depolama tekniklerinden faydalanılmıştır. Afet lojistiği operasyonlarının hayati operasyonlar olması sebebiyle tasarım adımlarının olabildiğince bağımsız olmasına dikkat edilmiştir. En üst tasarım adımından en alt tasarım adımına

kadar hiyerarşik olarak toplam 4 tasarım seviyesi oluşturulmuştur. Klasik lojistiğin boyutları dikkate alınarak, yalın lojistik perspektifi ile bir tasarım çalışmasının yapıldığı çalışmamızda tasarım parametrelerinin ne olması gerektiği ve tasarımın geçerliliğinin sağlanması amacıyla güncel literatürden faydalanılmıştır. Çalışmamızda hangi tasarım parametresi için literatürdeki hangi çalışmadan faydalandığına dair bir matris sunulmuştur.

Sonuçta ortaya koyulan tasarım ayrık, yalın ve yatay hiyerarşiye sahip bir tasarım yapısındadır. Hiyerarşinin daha fazla yataylaştırılması, operasyona yön veren bazı kritik tasarım adımlarının göz ardı edilmesine sebep olabileceği için mümkün olamamıştır. Aksiyomlarla Tasarım metodolojisinin genel olarak lojistik alanında, özel olarak ise yardım lojistiği alanında kullanımı çok yenidir ve bu bakış açısı ile çalışmanın özgün yönünü ifade etmektedir.