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# APPLYING THEORY OF CONSTRAINTS-THINKING PROCESSES IN LOGISTICS INDUSTRY: A CASE STUDY

## LOJİSTİK SEKTÖRÜNDE KISITLAR TEORİSİ DÜŞÜNCE SÜREÇLERİNİN UYGULANMASI: VAKA ÇALIŞMASI

**Ali İhsan BOYACI**

Kocaeli University, Department of Industrial Engineering, Kocaeli, Turkey
ali.ihsan@kocaeli.edu.tr

**Gülşen AKMAN**

Kocaeli University, Department of Industrial Engineering, Kocaeli, Turkey
akmang@kocaeli.edu.tr

## ABSTRACT

Maritime transport is one of the most important elements of the logistics sector and its importance is increasing day by day in our globalizing world. As a result of companies moving their trades to international dimensions, the increasing global transportation demand encourages the continuous development and growth of maritime transport. In this study, Theory of Constraints -Thinking Processes (TOC-TP) were applied to container terminal process which is one of the most important nodes of maritime transport.TP is an approach that aims to systematically reveal any limitations that prevent the existing system from functioning more efficiently, and to remove these limitations by generating reasonable and logical solutions.TP uses the techniques of Current Reality Tree, Evaporating Cloud, Future Reality Tree, Prerequisite Tree and Transitional Tree to accomplish these goals. It was aimed to increase the efficiency of container terminal processes by applying TOC-TP. For this purpose, problems were identified by analyzing the existing situation with the Current Reality Tree technique first, and then the Evaporating Cloud technique was used to define injections for removing the problems called undesired effects. The new situation that is expected to be achieved by applying the injections defined for solution of the problems was shown by using Future Reality Tree technique. Finally, the application prescription of the recommended injections to remove the root problems detected in the container terminal processes of the port operation was presented using Transition Tree technique.

**KeyWords:** Logistics, Theory of Constraints, Thinking Processes, Port Operation, Container Terminal Process

## ÖZET

Deniz taşımacılığı lojistik sektörünün en önemli unsurlarından birini oluşturmakta ve küreselleşen dünyamızda önemi her geçen gün daha da artmaktadır. İşletmelerin ticaretlerini uluslararası boyutlara taşıması sonucu artan küresel taşıma ihtiyacı deniz taşımacılığının sürekli olarak gelişmesini ve büyümesini teşvik etmektedir. Bu çalışmada deniz taşımacılığının en önemli düğümlerinden biri olan liman süreçlerine Kısıtlar Teorisi-Düşünce Süreçleri (KT-DS) uygulanmıştır.DS, mevcut sistemin daha verimli çalışmasını engelleyen her türlü sınırlamaları sistematik bir biçimde incelemek suretiyle ortaya çıkarmayı ve bu sınırlamaları çeşitli araçlar ile makul ve mantıklı çözümler üreterek ortadan kaldırmayı hedefleyen bir yaklaşımdır. DS bu amaçları gerçekleştirmek için, Mevcut Gerçeklik Ağacı (MGA), Buharlaşan Bulut (BB), Gelecek Gerçeklik Ağacı (GGA), Ön Koşul Ağacı (ÖKA) ve Geçiş Ağacı (GA) tekniklerinden yararlanır. Çalışmada gemi yükleme/tahliye ve konteyner terminal süreçlerine KT-DS uygulanarak liman ve konteyner terminal süreçlerinin verimliliğinin artırılması hedeflenmiştir. Bu amaçla öncelikle MGA tekniği ile mevcut durum analiz edilerek sorunlar tanımlanmış, daha sonra istenmeyen etki olarak adlandırılan problemlerin ortadan kaldırılması için BB tekniğinden yararlanılmıştır. Problemlerin çözümü için tanımlanan enjeksiyonların uygulanması ile elde edilmesi planlanan durum GGA tekniği ile gösterilmiştir. Son olarak GA tekniğinden yararlanarak enjeksiyonların mevcut varsayımlar altında hayata geçiriliş planı sunulmuştur.

**Anahtar Kelimler:** Lojistik, Kısıtlar Teorisi, Düşünce Süreçleri, Liman İşletmesi, Konteyner Terminali

## 1. INTRODUCTION

Maritime transport is the most preferred type of transportation with the possibility of transporting various cargoes together, reliability, no overturning, minimum loss of goods, cheaper than airline, highway and railway, and its importance increases day by day (John et al., 2015) . In the logistics sector, the place and importance of national and international ports of maritime transport is quite high through these important advantages. Today, this importance is increasing with globalization, and maritime transport is an indispensable element of the supply chain of many international companies (Montwiłł, 2014). The most important operations of ports with such reserves are the loading and unloading of containers on freight vessels. These processes are performed with many types of cranes and equipment with various capacities and features.

The Theory of Constraints (TOC) was developed to find, manage and eliminate the factors that affect system performance negatively in order to improve the performance of any system. It is a philosophy management containing philosophies, disciplines and best practices specific to the sectors. (Rahman, 1998, Akman and Karakoç, 2005). A large part of TOC which see a business as a whole system instead of a group of independent processes is a theory based on Goldratt's (1990) works. The Thinking Processes (TP) is an effective tool which is used to identify constraints in the current system, identify strategies to remove these constraints, and search how these strategies will be implemented (Scoggin et al., 2003).

Port container terminals are highly sophisticated systems that require high-level coordination and efficiency to ensure a fast and efficient transportation (Ambrosino and Siri, 2015). On the other hand, the growth of marine container transportation with a high acceleration has greatly increased and continues to increase competition between port businesses (Günther and Kim, 2006). In increasingly competitive conditions, port businesses want to increase their performance and improve their efficiency by using innovative approaches to planning and managing complex systems. It is possible to increase the competitive performance of port container terminals by using new approaches such as information technology, Goldratt‘s Thinking Processes (Vis and de Koster, 2003). The opportunities and advantages provided by new and different approaches have led port businesses managers and researchers to work in this direction (Crainic and Kim, 2007).

In this study, maritime transport which is one of the most important and indispensable elements of global logistics is discussed and it is aimed to apply the methods of TOC to the problems encountered in container terminal processes which are very important for efficiency and capacity utilization at both national and international ports. Within the scope of the study, the current situation of the container terminal processes of an international harbor company operating in the Marmara region has been examined by the TP and suggestions for the necessary improvements have been presented. Thus, it is aimed to expand the application fields of TOC and to enable the companies operating in the maritime transport sector to work with higher performance.

In the second section of the study, information about TP of TOC is given and the literature about TP practices is presented especially in logistics activities. In the next section information about container terminal processes, ship loading / unloading operations were presented. In the fourth section, TP application of TOC to an international port company was explained step by step. In the last section of the study, the findings obtained by the study results were evaluated.

## 2. THEORY OF CONSTRAINTS- THINKING PROCESSES

For many organizations, the main objective is to work at higher efficiency rates in increasingly competitive conditions, and as a result of this, to become to a more profitable business. TOC advocating that there were constraints limiting businesses to get more profits was developed by Eliyahu M. Goldratt at the beginning of the 1980s (Rahman, 1998). TOC is a management philosophy that allows us to determine the constraints limiting to access the goal and to implement the necessary changes to remove them (Silha, 1999). TOC is defined as a process-oriented management philosophy that achieves the overall optimization of the system through continuous improvement of the management in the long term. Although the original purpose of the TOC was to improve the production system, TOC can be used many areas such as finance, measures, project management, supply chain, marketing, and management of an organization (Noh et.al, 2017). According TOC, any factor that limiting a businessto achieve to purpose of getting the profit is defined as a constraint. These factors include low demand, inadequate personnel or machine capacity,orunmotivated workers (Bilicik and Gençyılmaz, 2008). The main point of the TOC is that each constraint, in contrast to traditional thinking, is a progression opportunity. TOC evaluates constraints as positive because the constraints define the performance of a system and gradually increase the system performance by removing constraint gradually (Akman and Karakoç, 2005)

TOC considers each system as a chain and it prescribes every time to focus on the weakest link of the chain and its system components. Because performance of the system is determined by the load which the chain can carry, and this load is the load that the weakest link in the chain can carry. If this link is strengthened, the overall performance of the system will increase (Filiz, 2008). After this link is strengthened, another constraint will appear and the new focus point will be this constraint. Therefore, by means of TOC, to improve system performance is aimed by continuous improvement on the system. Goldratt (1990) rejects the induction rule which is known as healing the whole system by healing the system by dividing the system into small pieces and then combining the healed pieces.

TOC uses various tools providing to concentrate on the main problems of the system and to create solutions to specify and remove constraints that prevent it from working more efficiently. Thinking Processes (TP) is one of these tools, and it involves the examination of the constraints that limit the performance of the system, proposing logical and reasonable solutions, finding the prerequisitons for the proposed solutions, and the elimination of difficulties during implementation (Chowdhary, 2009). The TP is intended to describe the necessary activities to develop the current situation of a system and thus to provide solutions to umbiguous situations (Stein, 1997). Although TP was originally developed and implemented for manufacturing systems, it has also been seen that of this philosophy can be successfully implemented in the service sector such as the logistics activities it can be successfully implemented and can be applied in many fields (Taylor et al., 2006). Rahman (2002) applied TP of TOC in supply chain management. Thus, it did not only determined critical success factors related to supply chain management, but also tried to determine the causal relationship between these factors.

In the philosophy of TP, system performance is tried to improve by looking for answers such as "What to change?", "What to change to" and "How to cause the change?" (Rahman, 1998). In this answer searching process, the Current Reality Tree, the Evaporating Cloud, the Future Reality Tree, the Pre-requisite Tree, and the Transition Tree tools are used. In TP philosophy, the purposes of asking these questions, the methods used to answer them and the summary explanations are given in Table 1.

Table1. Steps of Thinking Processes and Used Methods (Akman and Ural, 2011)

| QUESTIONS | GOAL | METHODS | EXPLANATIONS |
|---|---|---|---|
| What to change? | To define core problems | Current Reality Tree | It is designed to analyze the current situation of a system and understand the problems better, and It defines to define the core problems with undesirable effects reducing the performance of the system. |
| What to change to? | To develop simple and practical solutions | Evaporating Cloud | It involves separate tackling of problems, identifying encountered conflicts and to determining assumptions and examining them for solution |
| | | Future Reality Tree | It shows the cause-effect relationship between the changes that will be made in the current system and the results that can come into play. |
| How to cause the change? | To implement solutions | Pre-requisite Tree | In order to constitute the secondary solution needed to be up to all the obstacles in front of the solution idea provides a logical way to create clusters. |
| | | Transition Tree | It is used to define the necessary to achieve the goal. It is a cause-and-effect chain designed to reveal step-by-step processes from the definition of an undesirable outcome to the realization of change. |

### 2.1. What to change?

The question "what to change?" is foranalysing current system better and revealing the basic problems (constraints) that prevent the system from working more efficiently (Burton-Houle, 2001). Bringing a system to a better situation often requires it to change, but change can sometimes lead to poor results. In this case, that the change can only result in an improvement is a reality when the right component is correctly focused. Therefore, it is very important to determine the answer of the question "What to change?" correctly. For this purpose, firstly the main problem symptoms are identified and listed. These symptoms, called undesirable effects (UDEs), are examined in the cause-effect rationale and are revealed the core problems that must be removed. The current reality tree (CRT) diagram is used at this stage where the UDEs are examined in the cause-and-effect and the current situation is revealed.

Current Reality Tree (CRT):CRT is a problem analysis tool that attempts to express cause-effect relations in the existing system in a logical structure (Scoggin et al., 2003). The CRTprocess starts with the observation of UDEs and establishes system models within format of "IF .. THEN .." with rigorous logic rules (Taylor and Churchwell, 2004). This model is examined with logical constructs to make sure that the perceptions about the system are real, and then evaluated for the discovery of the core problem. The situations that cause the relationship in the MGA structure are situations that lead to observe reality, and helps to the researcher in revealing the core problem.

### 2.2. What to change to?

After defining the existing constraints by analyzing the existing system and and their root causes, logical, reasonable and practical solution strategies for core problems are searched with the question 'What to change to?' (Burton-Houle, 2001). The goal in this phase is to determine what will constraints preventing the system from working more efficiently transformt to. In this phase, the Evaporating Cloud (EC) and the Future Reality Tree (FRT) are utilized.

Evaporated Cloud (EC):EC is a tree structure required to identify reasonable and permanent solutions to core problem unrevealing by MGA (Rahman, 2002). The ECserves as an effective bridge by contributing to abolish problems to pass on to from the current situation to the desired future state (Davies et al., 2005). When CR is being created, the logical thinking process "... to make, we must do, because ..." are usually used. With the injections defined at the EC stage, it is aimed at eliminating the ongoing conflicts and turning UDEs into desired effects (RitsonandWaterfield, 2005).

Future Reality Tree (FRT): According to Goldratt (1994), FRT is a thinking process technique that, when implemented, enables the creation of solutions by transforming UDEs in the existing system into desired effects without creating new ones. While CRT begins with the observation of UDEs, FRT begins with the idea of how to reach the desired effect options. FRT is created by adding injections to CRT and with this tool, it is logically indicated that the desired effects can be achieved when injections are applied (Burton-Houle, 2001). FRT ensures that the solution is evaluated and developed before implementation starts, and it also ensures that what is missing in the solution is noticed.

### 2.3. How to cause the change?

With the question "How to cause the change?", It is sought to answer how to implement the proposed solution strategies incrementally by increasing the performance of the system by removing the system limitations (Burton-Houle, 2001). In this phase, the pre-requisite tree (PRT) and transition tree techniques are used.

Pre-Requisite Tree (PRT):It is a technique for predicting the problems that may arise during the process of reaching the situation set out and taking measures to eliminate these problems. PRT defines and evaluated obstacles that can occur at the stage of transforming of UDEs to desired effects (Ritson and Waterfield, 2005).

Transition Tree: The transition tree is basically the application prescription for the change needed to improve system performance. The transition tree is a step-by-step implementation plan of the actions to be taken to achieve the target situation identified by the FTR. This structure provides the transition from the current situation to the desired situation. Transition tree is a cause-and-effect chain that begins with UDEs and ends with the desired change (Chowdhary, 2009). In transition tree, how the change process step-by-step is performed is shown in the cause-and-effect relationship.

## 3. APPLICATION OF TOC-TP IN A PORT OPERATION

### 3.1. Ports And Container Terminal Processes

Rapidly growing globalization, communication and technology offer and even encourage producers to make their production in various parts of the world less costly and to expand their market space over the ocean. Along with this, it is becoming possible for customers to obtain the desired products at a lower cost from the various regions of the world.As a result, the need for goods to be transported to transoceanic countries is increasing, and maritime transport becomes more important.

Maritime transport is the most preferred type of transportation and its importance is increasing day by day because of the reasons such as the possibility of carrying various cargoes, high reliability, high delivery performance and being relatively cheap. The ports that form the node point in the fulfillment of a large number of activities in the national and international transport chain operate as integrated logistics centers with various functions such as ship loading / unloading and container storage (Montwiłł, 2014).

In today's world, ports and container terminals are the most important transportation infrastructures in maritime transportation, which constitutes a very important sub-component of global supply chain and logistics today (Akçetin, 2010).Container terminals, which play a critical role in the globalizing world economy, are important nodes of the sea cargo transportation network (Sun et al., 2011).The container terminal shown in Figure 1 is basically composed of the berth area where the vessels approach and the storage area where containers are temporarily stored.

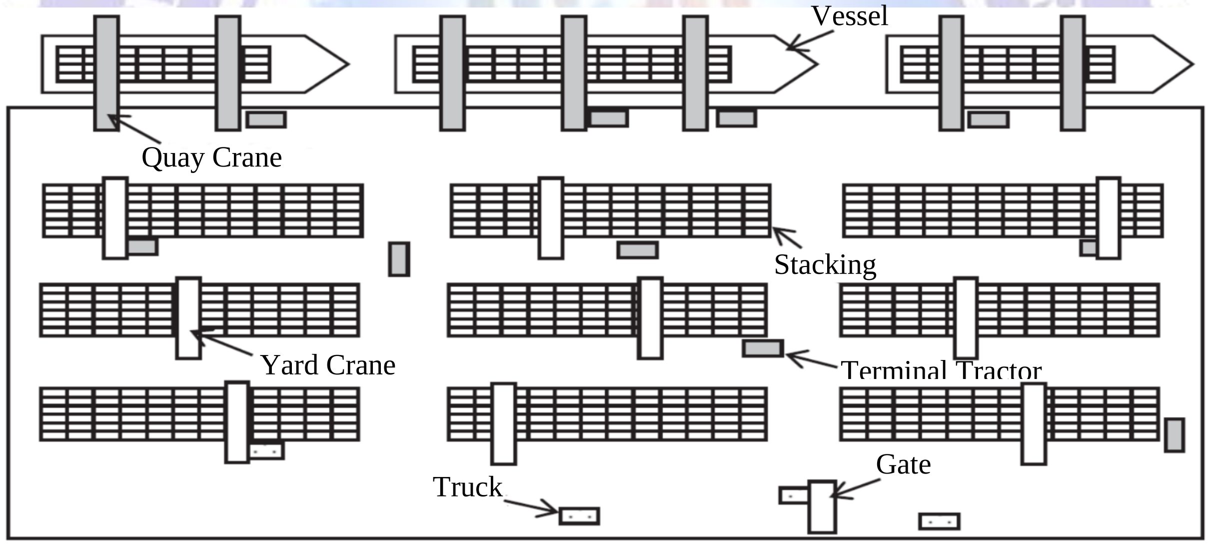


Figure 1: A container terminal and its equipment (Sun et al., 2011)

Processes in the container terminals begin with the arrival of a container vessel or the arrival of a container from the land to the container terminal. These processes generally include the assignment of vessels to berths (berth planning), the allocation of quay cranes and terminal tractors (TT) to vessels, the storage and sorting of containers at container terminal, the assignment of yard cranes for container handling at container terminal and the scheduling of workforce at ports.

Equipments such as quay crane, yard crane and TT are used to perform these tasks in the container terminals. From these equipments, quay cranes which can be rail or mobile are used tohandle containers between ship and land. TTs are vehicles used to transport containers within the port area. Yard cranes located in the stacking area are equipment that transport the containers between the stacking area and the conveying vehicles.

### 3.2. Container loading / unloading processes

In a container terminal, the vessels arrive at the port according to a predetermined schedule. Then, quay cranes assigned to the ship either load the containers to the ship in accordance with the ship's schedule, or unload containers from ship to the TT.TTs carry containers between field cranes and dock cranes. The yard cranes carry out the container transfer between the stacking area and the TTs. The flow chart of ship loading and unloading processes carried out in the container terminals is shown in Figure 2.

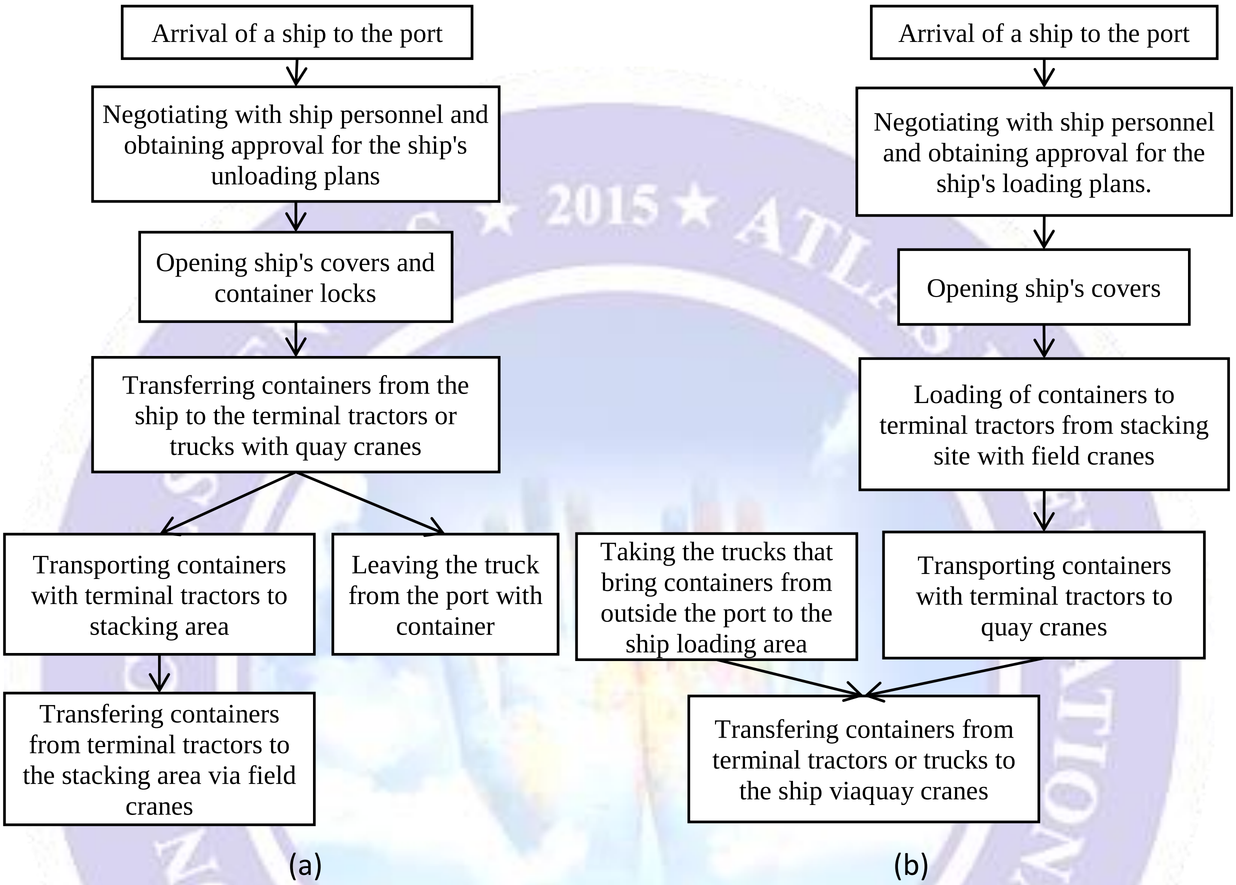


Figure 2: (a) Ship unloading process flow chart; (b) Ship loading process flow chart

Ship unloading process begins with the ship's arrival at the port and continues with negotiating with the ship's personnel and obtaining approval for the unloading plan.Afterwards, according to the volume of the container to be processed, quay crane and TT appointments are madeby the planning personnel for unloading containers from the relevant ship.After this phase, the necessary job orders are sent to the related quay cranes and TTs operators and the unloading process is actually started. If the container taken from the ship with quay crane is to exit directly from the port without being stacked, then the container is loaded onto a truck and removed from the port. If the container is to be stacked in the port, it is transported by TT to the stacking area determined by the planning team.

In the same way, ship loading process begins with the ship's arrival at the port and continues with negotiating with the ship's personnel and obtaining approval for the loading plan. Afterwards, according to the volume of the container to be loaded, quay crane and TT appointments are made by the planning personnel for loading containers to the ship.After this phase, the necessary job orders are sent to the related quay cranes and TTs operators and the loading process is actually started. If the containers to be loaded on the ship are stored in the yard stack, they are first transferred to TT with field cranes and then transported to quay cranes with TT. Containers to be loaded directly onto the ship without being stored in the yard stack are transported to the quay crane by trucks coming from the land. Finally, quay cranes load containers from TTs or trucks to the ship in accordance with the loading plan.

## 4. APPLICATION

In this study, the container terminal processes of an international port, operating in the Marmara region, has been examined. The port is located in a total area of 265,000 m2, with a berth of 1171 meters and a storage area of 457,000 TEU containers. More than a thousand international freight ships arrive in this port every year, and container terminal processes have a very important position in terms of efficiency in the port where more than one thousand international cargo ships berth each year

As explained in Section 3.1, container terminal of the port is also a highly complex system that requires high-level coordination and planning. For instance, in dock planning, ships should be assigned to available berths according to their arrival time, and quay cranes and TTs to serve each ship should be allocated. However, in the present case, the arrival time of the vessels to the port may not be realized as planned due to unforeseen reasons, so that dock assignments and resource and equipment allocations may have to be changed by making instantaneous decisions.

Ineffectiveness in planning and coordination of container terminal processes in the port reduces port efficiency and affects the competitive performance of the port in the negative direction. For example, most of the time, TTs and trucks coming from land to take or leave containers wait for yard cranes or quay cranes. As the TTs are waiting in the stacking area, the quay cranes are also waiting for the TTs and thus the equipment utilization rate and productivity are affected negatively.

The fact that the container terminal is not large enough for low floor stacking causes planning activities to be very important and critical in terms of efficiency. For example, if the container to be loaded from the stacking area to the TT is stacked on the lower floors, it is necessary for the crane operator to first move the containers above it and then receive the desired container. This situation, called ‘shifting’, affects the use of equipment and process efficiency negatively. Because of multi-storey stacking at the container terminal of the port, the current shifting rate is quite high.

In this study, firstly, a large team including the managers and employees of the port was established. Then, container terminal processes were investigated with KT-DS in order to improve the planning and coordination of the container terminal, to increase its productivity and thus to increase its competitive performance.

In this context, with the question of "What to change?", constraints that lowered the port container terminal's performance are investigated, and with the question of “What to change to?”, reasonable solution strategies for root problems have been researched, and with the question of “How to cause the change?”, it has been decided how the solution strategies will be implemented.

### 4.1. What to Change?

The first step of the KT-DS is to decide what to change. For this purpose, UDEs which are targeted to be eliminated by change should be determined. In this direction, firstly a team consisting of managers and employees was established and then the UDEs relating to container terminal processes of the port were determined with the brain storm as follows;

UDE1. Cranes and TTs assignment can not be made on time for each ship.

UDE2. TTs and quay cranes are waiting for each other to take or leave containers.

UDE3. Employees are unhappy with working at the port because they think their salaries are low.

UDE4. Working environment is very stressful and accident rates are high.

Based on these UDEs, the CRT constructed for the container terminal processes of the port is presented in Figure 3. With the CRT technique, the cause problems that caused adverse effects in container terminal processes were identified and marked with (*) on the figure. The CRT can be read from the bottom up using "if ... then ..." statements. For example, the CRT can be read upwards as "if the site planning office is inadequate, the stacking site cannot be planned well" or "if the ship plans arrive late to the operational unit, the quay cranes load the containers late on the ship".

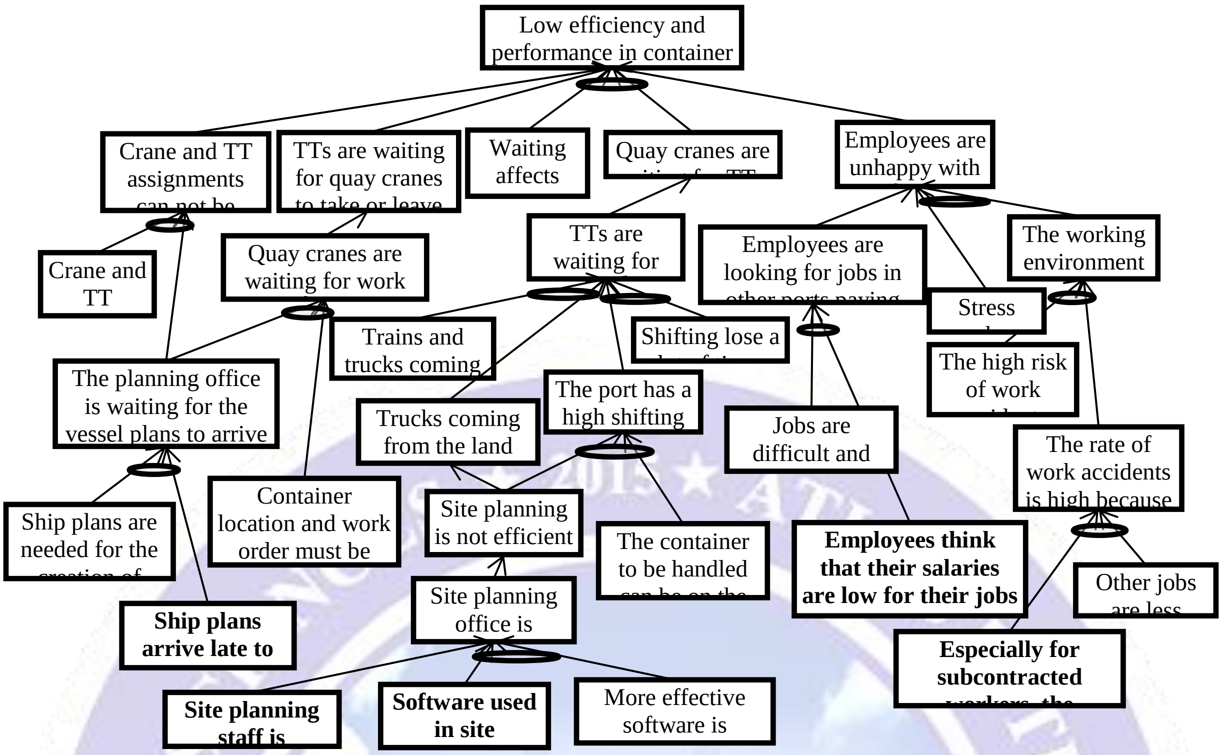


Figure 3. Current Reality Tree

### 4.2. What to Change to?

Using the information in Section 2, the ECs were created for the solution of each of the five root problems that existed in the container terminal processes of the port operation.

The logical thinking process in the first EC shown in Figure 4 is that "ship plans must arrive at the planning office on time so that the cranes and TT assignments for each ship can be timely". At the same time, in order for ship plans to arrive on time, captains must send their plans in time or be aware that they should be sent on time. The fact that the captains are aware of the need to send ship plans on time and that they do not create a conflict situation. In order to remove this conflict and evaporate the cloud, two injections, as shown in Figure 4, are defined.

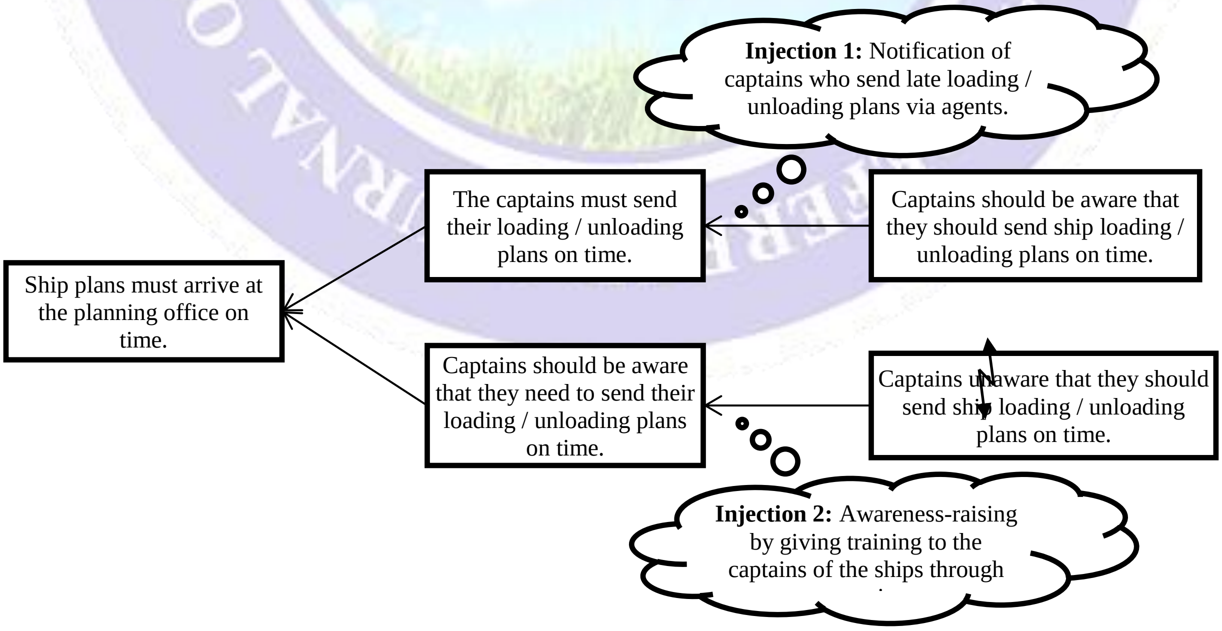


Figure 4: Evaporating Cloud relating late arrivals problem of ship plans

In the second EC, shown in Figure 5, the logical thinking process is "the software used in the site planning must be sufficient so that the berth cranes do not wait for TTs". At the same time, in order for the software used in the site planning to be sufficient, the software must be updated by the software company to be more effective, or new software must be used instead of the existing software. In this case, continuing to use existing software or replacing it with new software creates a conflict situation. In order to remove this conflict and evaporate the cloud, two injections, as shown in Figure 5, are defined.

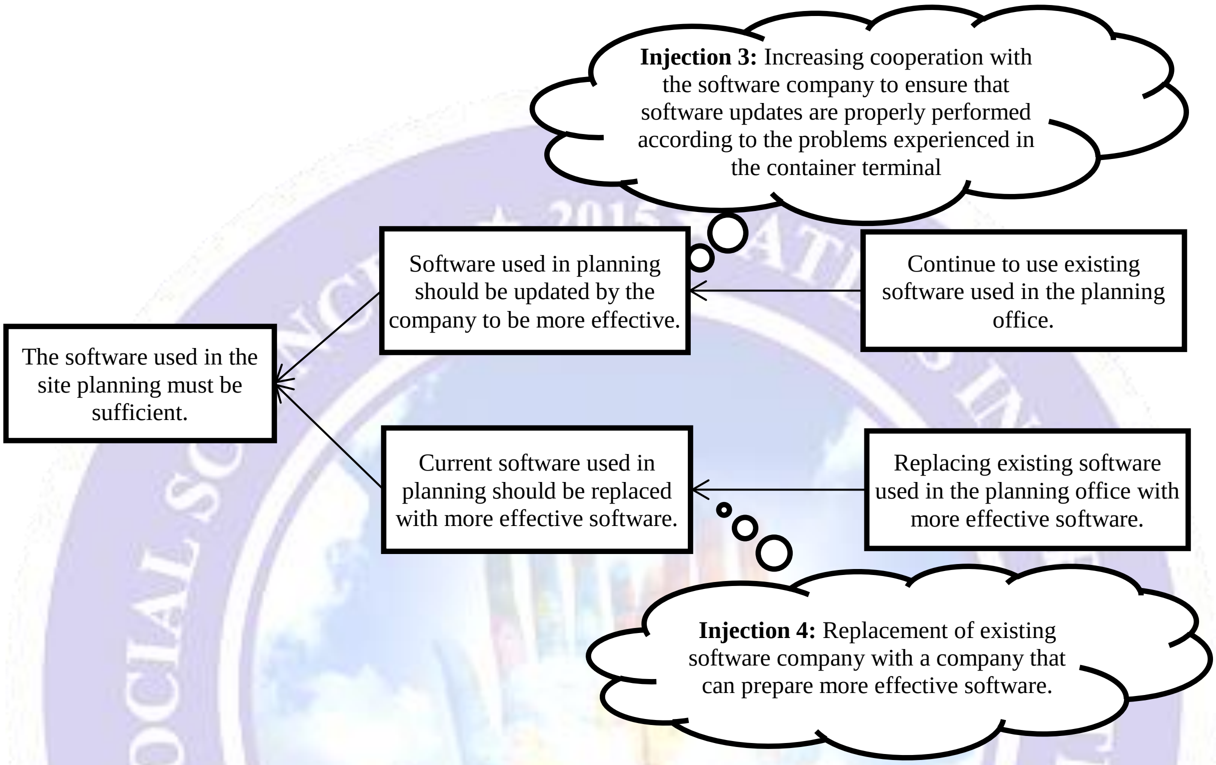


Figure 5: Evaporating Cloud relating problem of inadequacy of used software

In the third EC, shown in Figure 6, there is a conflict between two situations regarding the knowledge level of the planning staff. In order to remove this conflict and evaporate the cloud, two injections, as shown in the figure, are defined.

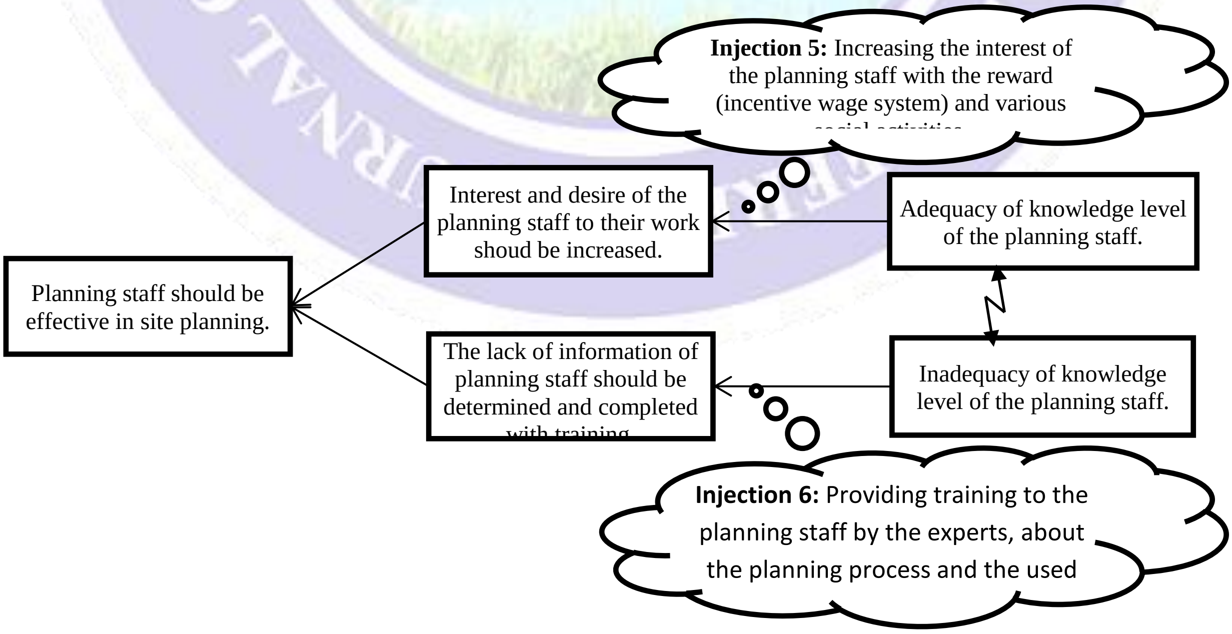


Figure 6: Evaporating Cloud relating problem of inadequacy of planning staff

In the fourth EC, shown in Figure 7, there is a conflict between two situations about the satisfaction of employees at the port. This conflict lies in the fact that the salaries paid by the port operation to employees are above or below the overall average. In order to remove this conflict and evaporate the cloud, two injections, as shown in the figure, are defined.

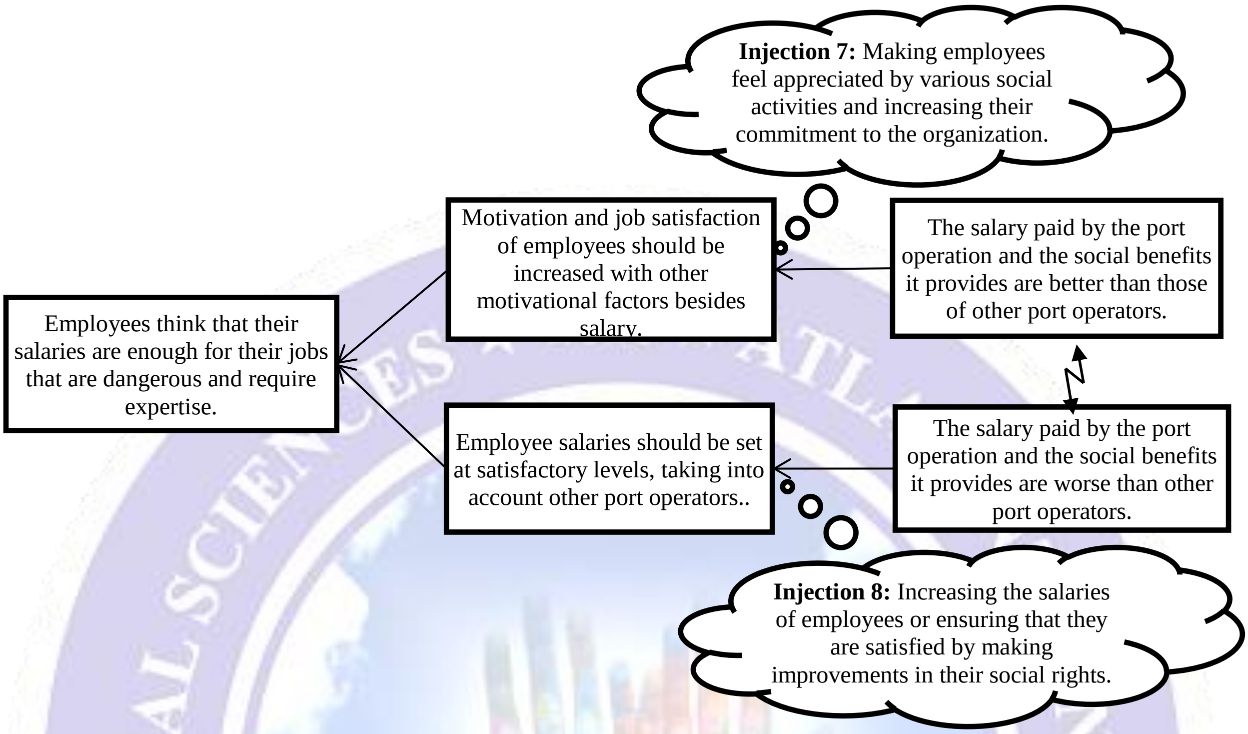


Figure 7: Evaporating Cloud relating problem of employee salaries

The logical thinking process in the fifth EC, shown in Figure 8, is "the work environment for subcontracted workers must be improved in order to ensure that the working environment is not stressful and the accident rates are low". In this evaporating cloud, occupational health and safety practices are creating conflict where necessary attention and care is given and not given by employees. Two injections are defined as shown in the figure to remove this conflict and evaporate the cloud.

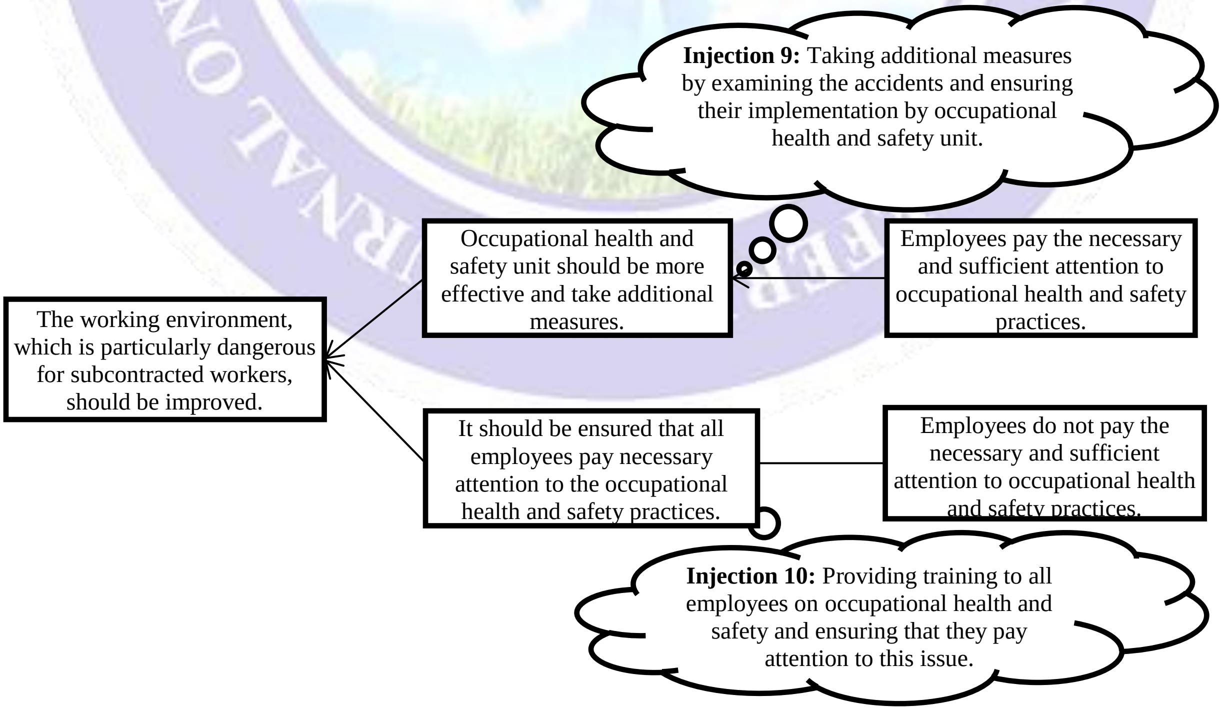


Figure 8: Evaporating Cloud relating problem of dangerous working environment

The FRT, presented in Figure 9, was created with the help of CRT and the injections defined in the ECs for the container terminal processes of the port operation. The FRT can also be read from the bottom up using the "if ... then ..." statements, like CRT. For example, the FRT can be read upwards as "If the vessel plans arrive at the planning office on time, the planning office does not wait to create work orders and perform resource assignments" or "if the TTs do not wait for yard cranes to leave or receive containers, the quay cranes will not wait for TTs".

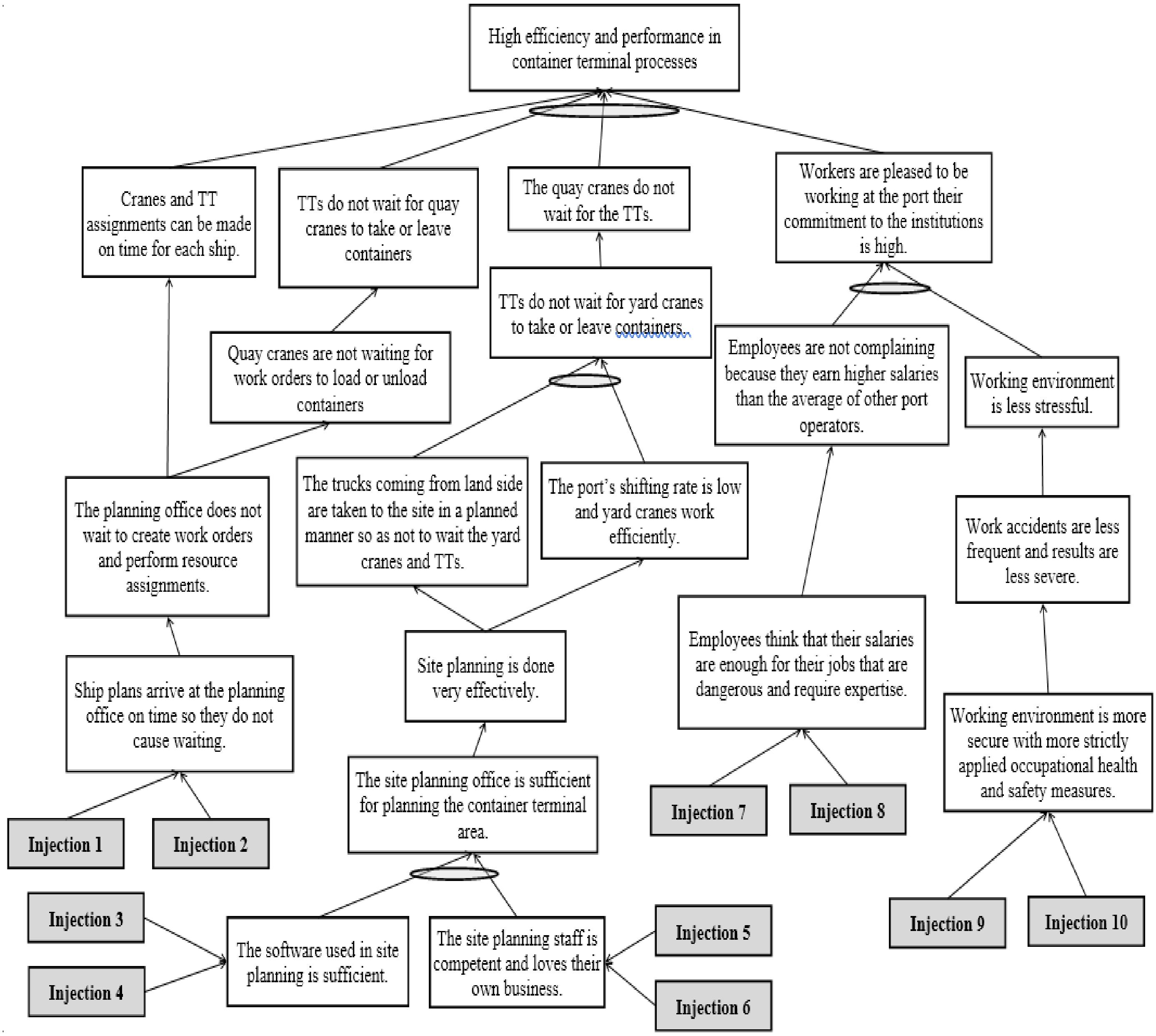


Figure 9: Future Reality Tree

### 4.3. How to Cause the Change?

Transition Trees, which are the application prescription of the recommended injections to remove the root problems detected in the container terminal processes of the port operation, are presented separately for each root problem in this section. The transitional tree shown in Figure 10 presents a recipe for the implementation of the solution proposals for the problem that ship plans do not arrive at the operational unit on time. As it can be seen from the figure, on the right side, the assumptions about the current system are shown. On the left side, there are activities that need to be done to remove the problem.

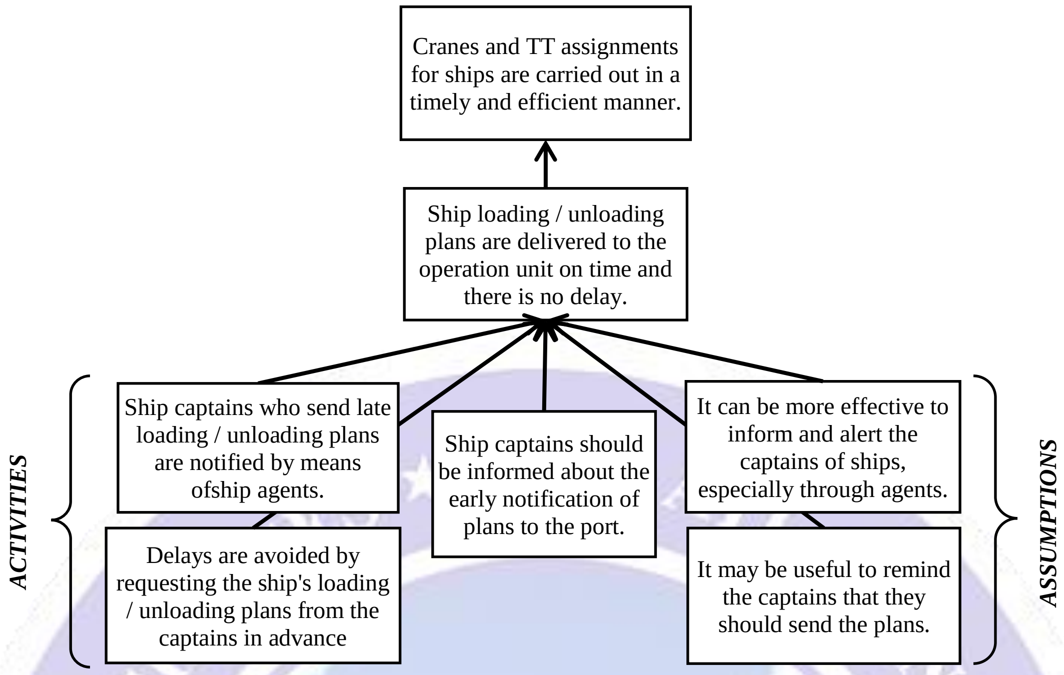


Figure 10: Transition Tree relating late arrivals problem of ship plans

The transitional tree, which is the application prescription of injections for the problem of ineffectiveness of planning staff is presented in Figure 11. This transition process is planned considering the existing assumptions on the right side of the tree.

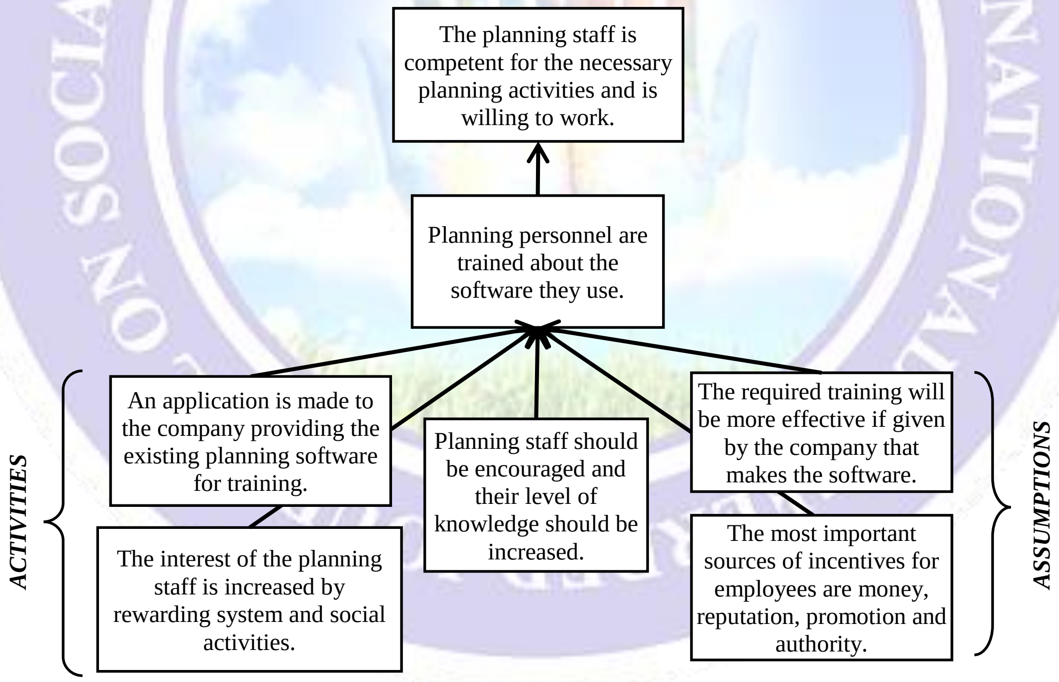


Figure 11: Transition Tree relating the problem of inadequacy of planning staff

In Transition Tree shown in Figure 12, the problem of inadequate software used to plan the container terminal processes has been discussed and the implementation plan of the injections to solve this problem has been presented.

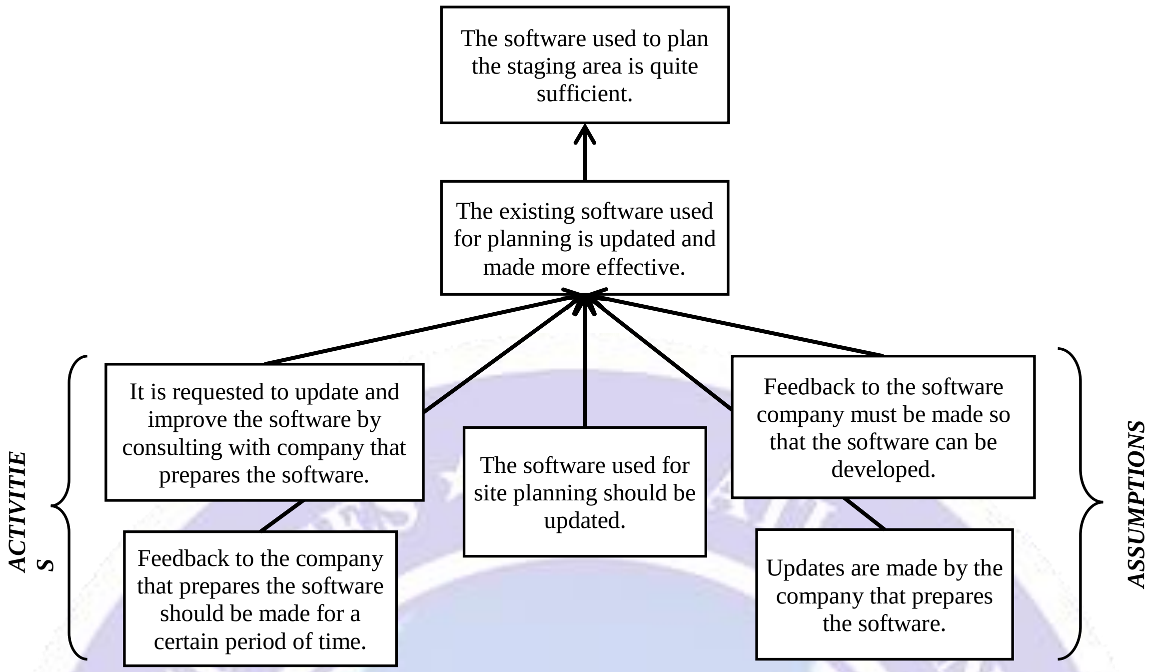


Figure 12: Transition Tree relating problem of inadequacy of used software

Transition Tree shown in Figure 13, presents a recipe for implementation of the solution proposals for the problem of employees thinking that their salaries are low for their jobs that are dangerous and require expertise.

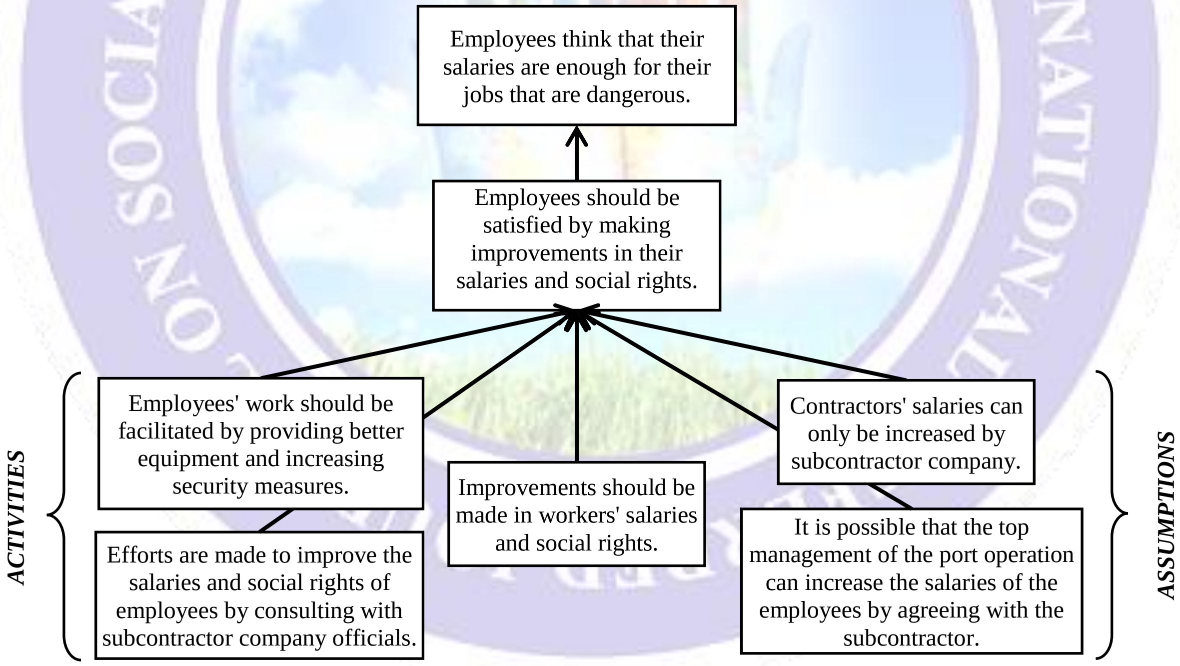


Figure 13: Transition Tree relating problem of employee salaries

In the transition tree shown in Figure 14, the implementation plan of the proposed injections is presented for solving the problem that the working environment is dangerous for subcontracted workers and that employees do not feel safe.

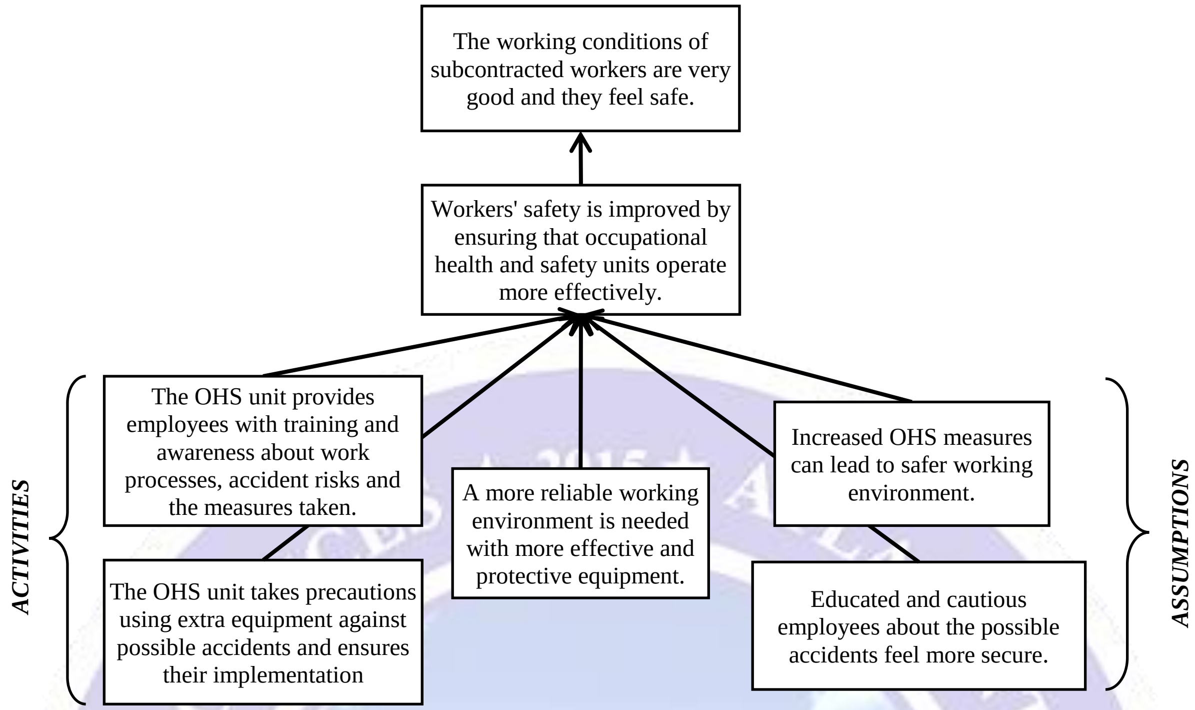


Figure 14: Transition Tree relating problem of dangerous working environment

## 5. CONCLUSION

Today, maritime transport has a number of advantages over other transport types, and it is an indispensable part of the supply chain of companies with markets and / or suppliers, especially in remote geographical regions. The performance of port operators, one of the most important elements of maritime transport, is being tried to be increased in order to meet the increasing demand and to make more profit, and many academic studies are being done for this purpose. Container terminal processes, which have a key role in determining the performance of a port operator, are difficult to manage due to the limited port docks and equipment, complexity and multi-dimensional planning.

In this study, TOC-TP was applied to the container terminal processes of an international port operation, operating in the Marmara region, and it was aimed to increase the performance of the port operation and to enlarge the application area of TOC-TP. For this purpose, firstly, by analyzing the situation of the container terminal processes with the CRT approach, which is one of the tools of the TOC-TPphilosophy, the root causes of the problems that prevent the system from working more effectively have been tried to be found. For this purpose, a large working group, including both field workers and managers, was established and direct observations were made. The existing root problems in the port have been suggested as the inability of timely delivery of ship plans to the operation unit, the inadequacy of the site planning staff, workers thinking that their salaries are low for dangerous jobs they do, the inadequacy of the software used for the site planning and the dangerous working environment especially for the subcontracted workers.

In the second stage, in order to remove the undesirable effects, injections have been defined using EC approach for each root problem and solution proposals have been developed. Then, the new system which can be obtained by removing the root problems by applying injections, with FRT approach of TOC-TP philosophy, has been introduced. Finally, with the TT technique, implementation plans of the changes taking into account existing assumptions are presented. It is concluded from this study that it is possible to successfully apply the TOC-TP philosophy to port operators. It is hoped that this work could also be useful for other port operators.

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