Review on Cargo Space Optimization

Jyoti T. Patil¹, Manoj E. Patil²
¹Research Scholar, ²Associate Professor
Department of Computer Engineering,
SSBT College of Engineering & Technology,
Bambhori, Jalgaon-425001, Maharashtra, India

Abstract — Cargo loading is the most essential factor in transportation like Indian railways, airlines, trucks, buses. It is the proper arrangement of goods or items into the available space of container. The shipping charges for this are very high due to high cost of fuels. The cargo loading plans are available in USA, China. They have considered homogeneous sets of cargos and different optimization models. Due to improper arrangement or unavailability of proper optimization techniques the space gets wasted and damage of goods occurs in Indian railways, airlines, trucks, buses. So, the optimization algorithm & model is required. The paper presents general architecture of cargo space optimization model.

Keywords — Operational Research, Cargo Loading, Space Optimization.

I. INTRODUCTION

The cargo loading is the part of the operational research. The activities carried out in an organization are called as operations. The process of observation and testing characterized by the scientific method. Situation, problem statement, model construction, validation, experimentation, candidate solutions is called research. So the operational research is a collection of general mathematical models, analytical procedures, and algorithms.

Operational researchers or professionals aim to provide a rational basis for decision making by seeking to understand and structure complex situations and to use this understanding to predict system behavior & improve system performance. Much of this work is done using analytical and numerical techniques to develop and manipulate mathematical and computer models of organizational systems composed of people, machines & procedures. The cargo space optimization is the real time problem. Cargo load planning is critical to transport carriers, especially for an industry heavily influenced by increasing fuel prices & costs.

Cargo loading for containers is also a big issue. This is called as container loading problem. Container loading is an important operation in modern logistics. Thousands of containers gets loaded daily to large distribution centers like Indian railways, Indian airlines, buses, trucks.

Due to the increasing costs of fuels transporters have big challenge of this. Operational research is method of mathematically based analysis for providing a quantitative basis for management decisions. It is a decision support approach.

Cargo loading operations are still manual in many warehouses. Cargo loading operations involves the problems like:-
1. How to determine the minimum number of containers that are required for loading.
2. How to load that container properly.

The major categories of cargo loading plans include storage & retrieval system, container loading techniques etc.

The effective cargo optimization & transportation needs some considerations like:-

The structure of the system under certain circumstances & limitations. The performance of the system is also the most important factor. The quality of system & it can be used in real time platforms like railways airlines etc.

General cargos loading are packing the goods or cargos from source & dispatch it from destination as given in Fig 1.

Fig. 1 shows the general architecture of cargo loading plans. Generally customer puts the objects in trains or airline with the help of software. Customer has to fill the details of the cargo & have to request to pack the cargo properly. This whole information gets stored in the databases of those systems. The cargo gets loaded properly from source. At the destination point the system unloads the cargo properly. While transportation of these cargos care of delicate cargo must be taken. At destination point the unpacking of the cargo takes place & properly given to the customers by using the databases information.

II. RELATED WORK

The cargo space optimization is the real time problem. Cargo load planning is critical to transport carriers,
especially for an industry heavily influenced by increasing fuel prices and costs. Loading cargos of different sizes is a highly complex and difficult task. Currently, logistics companies with many years of cumulative practical experience manage such tasks. However, due to different sizes and cargo types, loading workers often spend many hours arranging and stacking cargoes based on trial and error methods or rules of thumb. To fit the cargo into the same container, the direction and position of cargoes must often be changed numerous times, even when cargoes that are originally in place would have to be removed and repositioned. Such a practice is certainly a timely burden with no financial benefits, and it cannot guarantee that the objective of a secure, stable, and optimized.

Cunlu et al., in [6], proposed a two-stage decision support system for a two stage air cargo loading plan. Since air pallets have different shape and size specifications, they belong to a three-dimensional bin-packing problem. Thus, the first stage involved the use of linear planning to determine the lower limit for the overall cost of the pallet relative to weight and quantity. The second stage involved the creation of a loading plan for each pallet. Yan et al. (2008) developed a stochastic demand cargo container loading plan model for the air express industry. The model belongs to a class of non-linear mixed integer programming programs designed to minimize total operation costs of pallet management under associated operational limits. The aforementioned studies reveal that practical.

Cargo loading operation involves two problems: determining the minimum number of containers that are required and loading each container to better utilize its capacity. Mathematically, the cargo loading problem can be seen as a specific aspect of the three-dimensional bin packing problem (3BPP), i.e., allocating without overlapping a finite set of rectangular items (cargos) into bins (containers) so as to meet certain objectives. Some examples are:

- Number of the bins should be minimized to pack all items.
- The total volume of items should be maximized so that can be packed into one bin.
- Find a method to pack all given items into one bin.

In real applications, certain constraints are often added to the optimization process. For example, item orientation, spatial relationship, packing sequence, etc. These additional constraints further complicate the process to optimize the objectives. Generally speaking, the cargo loading problem is NP-hard. Therefore, heuristic methods are often used for its solution [2].

The cargo space optimization is the problem of utilization of maximum space available in railways, airlines etc. There are various works done in USA by considering some optimization algorithms and models.

H. Gehring and A. Bortfelt, in [1], present the genetic algorithm for container loading problem. The main idea is to loading the strongly homogeneous set of boxes into a single container. The approach includes generation of a set of disjunctive box towers & to arrange the box towers on the floors of the container. The stability, balance constraints are considered. The algorithm can be applied to only homogeneous set of boxes (rectangles). So for the heterogeneous sets of cargo the constraints are considered like Orientation constraint, Top placement constraint, Weight constraint, Stability constraint & Balance constraint [1].

- Orientation constraint:- Each box in the given subset of boxes is to be placed in restricted way
- Top placement constraint: - None of the boxes in a given subset may bear a weight: placing further boxes on the top of these boxes is not allowed.
- Weight constraint: - Weight must not exceed certain given limit.
- Stability constraint: - Demands that the stability of all boxes does not fall below a given amount.
- Balance constraint: - Balanced cargo criteria must be followed.

Li Pan et al., in [2], presents the cargo optimization problem is considered as a NP-hard problem. Tabu search approach is used to solve the problem. It is a tree based heuristic cargo loading approach. This approach is more flexible in taking different box conditions into considerations. Tabu search framework is used to further optimize the packing plan by repacking some containers with different subsets of items to reduce the number of containers that are finally needed. In this optimization process, utilization of capacity of some containers is increased. The approach is based on in which the search scheme and neighborhood size are independent of the specific problem to be solved and the neighborhood size and structure are varied dynamically during the search procedure.

Kelly Fok, Ming Ka et al., in [3], presents that the design & prototype of a Web-based application for air cargo load analysis and planning is developed which is called as the CLPA System. It consists of, firstly to perform long-term forecasting based on an analysis of historical data and then secondly operational load planning with mathematical optimization. Two factors are important for load planning: weight and capacity. The CLPA System is a decision support system that can be used to evaluate past historical data on cargo space utilization so as to plan for long-term cargo sales Strategies, such as cargo allotment, contract amount with
Cargo agents and cargo rating. CLPA will also be used during operations to formulate the load plan using booking data to perform space optimization. At the current stage of the project, CLPA is only being tested for cargo load planning of passenger planes.

Tom Jose V, Sijo et al., in [4], aims to make a comparative study of different industry available softwares for cargo load optimization and planning such as 3D load packer, Load planner, the cube IQ load planning system, Auto load pro integrated 3D graphic technology, Cube master, The Packer3d Online Service etc. The focus is on a decision support system specifically designed for transport load planning of sea and air transport containers, trucks, boxes, and pallets, and is optimized with full auto loading capability using dynamic programming. PackVol is an Optimization Software for Load Planning, designed to plan the best space utilization inside containers and trucks, to help to reduce transportation costs. It is innovative software for MS Windows, which has some unique features not found in other container loading software products. It is truly tri dimensional; the program allows managing efficiently complex load planning problems [4].

III. CARGO LOADING & OPTIMIZATION MODELS

There are different cargo loading plans available in USA. The Cargo loading planning analysis is a system in which different strategies are considered like revenue management in case of air cargo management [5]. Air cargo is an indispensable part of airline business. When an aircraft carries passengers to its destination, its belly is utilized to carry cargo shipments. However, with an expected strong growth of cargo demand since 2010, airlines started to purchase dedicated cargo aircraft (freighters) to exclusively handle cargo shipments. Some carriers even set up an independent cargo division to take advantages from the upcoming demand surge. Nowadays, the cargo business accounts for more than 20% of the total revenue for many major carriers [4] [7].

A. Design of Cargo Optimization Model for Airlines

The airlines have very large transportation of cargos within two cities, states, countries. It is very challenging task for airlines to arrange the cargos according to passenger’s demands. They have to take care of cargo in case of damage & also have to consider the total capacity of available cargo space or container. Revenue management (RM) in air cargo consists of short and mid-term allocation processes. The short-term allocation process allocates available flight capacity to volatile spot market demand, and shippers are charged based on the floating market rate. Despite the volatility of the spot market, shippers in the spot market utilize their allocation more effectively as they request capacity only when they are (almost) certain about their shipments. Similarly to the allocation process for passenger RM, the short-term allocation process is run nightly to update the capacity allocation given the remaining capacity and updated demand forecast. The resulting allocation policy is then implemented next day to accept and reject shipment requests.

The mid-term allocation process is initiated when the carrier releases a new flight schedule. In the process, the carrier sells flight capacity in the form of allotments, which are simply reserved blocks of cargo space, to shippers through various capacity commitments. Those shippers can be freight forwarders (capacity resellers), large clients, and local station managers. Large clients usually receive a deep discount rate, but still account for a significant portion of the total revenue. Local station managers are essentially freight forwards owned by the carrier. However, they only consider the amount of space that they should acquire on flights that depart from their stations. This provides details about the mid-term allocation process in practice. It starts in the first week when the tentative flight schedule for the next six months is released. After receiving the new flight schedule, each shipper/bidder prepares an allotment bid with a bidding price, shipment schedule, and capacity requirements measured in weight, volume, and the number and type of unit load devices [7].

B. Design of Cargo Optimization Model for Indian Railways

In case of Indian Railways, large transportation takes place from source to destinations i.e. between 2 stations. The customers have to put their luggage or cargo in proper way & it is also the responsibility of railways systems. The architecture of cargo space optimization is given in Fig. 2. There must be the proper optimization model for this purpose. Some suggestions are as follows:-

- The passenger should be allowed to put all types of cargos. It can be delicate cargo or hard cargo.
- There should be the criteria for arrangements of these cargos properly so that maximum space of available container can be used.
- The dispatch of the cargo should be according to passengers demands i.e. it should consider the destination station of the passenger.
- Some prioritization criteria should be considered so that big size & weighted cargos can be placed first & remaining can be placed in place available properly so that it will avoid damage of cargo.
Fig. 2: Architecture of cargo space optimization model.

It will be the well defined cargo space optimization model by considering all the above suggestions. Some optimization algorithms are available. As shown in Fig. 2, user login with the train no. & destination information option is available. The railway system uses the databases of passenger system & generates the list of all cargos according to their dimensions. All cargo gets adjusted properly in available space of container & remaining space gets displayed. The passenger can dispatch their cargo at destination. Greedy algorithms, genetic algorithms can be used for cargo loading operations. The algorithms should be designed by considering the length, width, height & weight of the cargos & also the container’s dimensions should be considered.

IV. CONCLUSION

The Cargo space optimization is the real time problem for Indian railways. It is the use of maximum available space in the given container. The different cargo loading plans are available in USA, China for airlines. The design of cargo optimization model for airlines is discussed. The architecture of cargo space optimization model is discussed. Different works has been considered while studying the cargo optimization.

In future work the focus will be on design of proper optimization algorithms & model for the Indian railways by considering the dimensions of the containers like weight, height & available cargo so that maximum space can be used for further transportation.

REFERENCES