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MODELING IN MARITIME EDUCATION

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ABSTRACT

The modeling method, which has been used in science and engineering for many years, could have a strong impact on maritime education. While the broad technological progress, which has taken place over recent years, has caused a great need for technology education, the existing educational structures have not developed at the same rate. Therefore, the modeling method in maritime education could be a scientific solution to a better understanding and, of course, for best solutions of the problems arise.

We briefly present the reasons for using modeling in maritime transportation. Starting from the classical transportation model, we build multidimensional maritime transportation models and indicate methods to solve these models. Further possibilities of investigation and modeling are also pointed out.

INTRODUCTION

Many applications of engineering and science make use of models. The term "model" is usually used for a structure, which has been used purposely to exhibit features and characteristics of some other objects. Generally only some of these features and characteristics will be retained in the model depending upon the use to which it is to be put.

The modeling method is built upon a mental activity, which allows one, through several logic operations, to process previously obtained information in order to create a theoretical model. This developed model is then reproduced as a practical model with which to experiment. The practical model reflects all theoretical functions and interactions, which can be easily performed, controlled and measured during an experiment.

The experimentally obtained results are essential to assess the practical model and to develop further or improve its status and features. After this process, the improved material is ready for next trial, which in this case is a large-scale experiment. This process can be repeated satisfactorily for several consecutive steps. After a number of iterations the final version of the model is reached.

Some models are concrete, but more often are abstract models, especially in operational research. These models will usually be mathematical in that algebraic symbolism will be used to mirror the internal relationships in the object (often an organization) being modeled.

There are a number of reasons for using modeling:
a) the actual exercise of building a model often reveals relationships, which were not apparent to many people.

b) having built a model it is usually possible to analyse it mathematically to help suggest courses, which might not otherwise be apparent.

c) experimentation is possible with a model whereas it is often not possible or desirable to experiment with the object being modeled. It would clearly be politically difficult, as well as undesirable, to experiment with unconventional economic measures in a country if there was a high probability of disastrous failure. The pursuit of such courageous experiments would be more (though not perhaps totally) acceptable on a mathematical model.

The essential feature of a mathematical model in operational research is that it involves a set of mathematical relationships (such as equations, inequalities, logical dependencies, etc.), which correspond to some more down-to-earth relationships in the real world (such as technological relationships, physical laws, marketing constraints, etc.).

MARITIME TRANSPORTATION MODELING

While the broad technological progress, which has taken place over recent years, has caused a great need for technology education, the existing educational structures have not developed at the same rate. Therefore, the modeling method in maritime transportation could be a scientific solution to a better understanding and, of course, for best solutions of the problems arise.

Firstly, we start from the classical transportation problem and explain why this model is not very good for maritime transportation. Then we improve the model by introducing the third index. Finally, multi-index transportation problems can be considered.

The classical transportation model assumes that the per unit cost for each potential origin destination pair is known a priori. The model doesn't take in consideration the type of ship, the various commodities to be transported, the different characteristics of the vessels and other factors, which also can influence the total cost of transportation. Therefore, we have to consider more indices to build realistic maritime transportation models. By introducing the third index for the types of goods transported, we obtain a three-dimensional maritime transportation model. It is very clear that the multidimensional transportation models could be very good representations of real situations, but the computational problems are really very difficult. More indices we introduce, more realistic the maritime transportation models become; in the same time, the problem becomes more and more difficult to solve.

Also, it cannot be assumed that carriers will be able to serve every origin destination pair for which they are the least-cost carrier because of capacity constraints on the various carriers. Consequently, it is impossible to assign, a priori, the appropriate per unit transportation costs necessary to use classic transportation problem.

Other major differences between classical transportation problems and ship problems could be:

- destination of ships may be changed at sea;
- ships are different from each other in their operating characteristics (capacity, speed), as well as their cost structure. Due to frequent fluctuations in the ship market, even two identical ships may have quite different cost structures;
- ships do not necessarily return to their origin;
- there are more sources of uncertainty and much longer voyages in maritime transportation.

A detailed analysis about the characteristics and the peculiarities of maritime transportation was made by D. Ronen [6].

All these arguments denote that the standard transportation model cannot apply to simulate ship problems.

Depending on the known dates and on the types of the constraints adequate to the problem, there are several three maritime transportation models. Taking into account their main characteristics, we can make a general unit presentation of the three dimensional case.

The objective function become

$$z = \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} c_{ijk} x_{ijk}$$

$I = \{1,..., m\}$, $J = \{1,..., n\}$, $K = \{1,...,p\}$ and where independent on the signification of indexes i, j, k in each model, $\{c_{ijk}\}$ represents the matrix of unit costs of transportation and $\{x_{ijk}\}$ represents the unknown matrix of commodities to be transported.

There are two distinct types of constraints for the variables x_{ijk}:

a. Planar Constraints (PC)

Fixing two indexes of the matrix $\{x_{ijk}\}$, i, j, the summation of x_{ijk}, for all k, should be equal to the elements of a real two indexes sequence a_{ij}:

$$\text{(PC)} \quad \sum_{k \in K} x_{ijk} = a_{ij}, \quad i \in I, j \in J$$

The structure of this constraints type imposes the existence of three distinct planar constraints, as maximum, one for each two indexes group $\{i, j\}$, $\{j, k\}$ and $\{i, k\}$, denoted by (PC1), (PC2) and (PC3):

$$\text{(PC1)} \quad \sum_{k \in K} x_{ijk} = a_{ij}, \quad i \in I, j \in J$$

$$\text{(PC2)} \quad \sum_{i \in I} x_{ijk} = b_{jk}, \quad j \in J, k \in K$$

$$\text{(PC3)} \quad \sum_{j \in J} x_{ijk} = c_{ik}, \quad i \in I, k \in K$$

b. Axial Constraints (AC)

Fixing one index of the matrix $\{x_{ijk}\}$, i.e. i, the double sum of x_{ijk}, for all j and k, should be equal to the elements of a real one index sequence a_i:

$$\text{(AC)} \quad \sum_{j \in J} \sum_{k \in K} x_{ijk} = a_i, \quad i \in I$$

Similarly to the planar case, the structure of this constraints type imposes the existence of three distinct axial constraints, as maximum, one for each i, j, k index, denoted by (AC1), (AC2) and (AC3):

$$\text{(AC1)} \quad \sum_{j \in J} \sum_{k \in K} x_{ijk} = a_i, \quad i \in I$$

$$\text{(AC2)} \quad \sum_{i \in I} \sum_{k \in K} x_{ijk} = b_j, \quad j \in J$$

$$\text{(AC3)} \quad \sum_{i \in I} \sum_{j \in J} x_{ijk} = c_k, \quad k \in K$$

According to the different types of constraints, the model will be called axial, planar or mixed. For every model, the known dates of the problem are distinct, but there are three compatibility relations (CR) between all these dates, which assure the mathematical equilibrium, as a consequence of the economic equilibrium between demand and supply:

$$\text{(CR1)} \quad \sum_{j \in J} a_{ij} = \sum_{k \in K} c_{ik} = a_i, i \in I$$

$$\text{(CR2)} \quad \sum_{i \in I} a_{ij} = \sum_{k \in K} b_{jk} = b_j, j \in J$$

$$\text{(CR3)} \quad \sum_{j \in J} b_{jk} = \sum_{i \in I} c_{ik} = c_k, k \in K$$

From the above compatibility relations, it follows the well-known equilibrium condition for the transportation problem:

$$\text{(EC)} \quad \sum_{i \in I} a_i = \sum_{j \in J} b_j = \sum_{k \in K} c_k$$

Applying the three dimensional maritime transportation models to carry homogeneous goods (containers, oil, chemicals, ore, etc.), we have to analyse the influence of different types of ships. Therefore, the third index *k* will define the type of vessel used to transport the commodity. We illustrate below the significance of all indexes and dates:

i the origin port (loading port)

j the destination port (unloading port)

k the type of vessel used to transport homogeneous commodity

c_{ijk} the unit cost of transportation from i to j using a k type vessel

x_{ijk} the amount of goods loaded in the origin port i to be transported in the port j with a k type ship, so that the total cost of transportation should be minimum

a_{ij} the amount of commodities transported from i to j

b_{jk} the amount of commodities demanded in the destination port j and transported with a k type vessel

c_{ik} the amount of goods transported from the origin port i with a k type ship

a_i the total amount of commodities stored in the port i

b_j the total amount of commodities demanded in the unloading port j

c_k the total amount of commodities transported with the k type ships.

The most important three dimensional transportation models are the three axial problem (the model which contains all three distinct types of axial constraints) and the three planar problem (contains all three distinct types of planar constraints).

Introducing a fourth index for the commodities transported, we obtain four dimensional maritime transportation models. These problems are more difficult to solve, but the models are more realistic, especially taking into account the ships, which can transport different types of goods.

K.B. Haley [3] is the author of the algorithm for solving the three planar transportation problems. His algorithm is an entirely spreading of "modi method", a refinement of simplex applied to the classical transportation problem (G.B. Dantzig). We have to point out that some problems remain concerning the computational aspects and also nothing for its solution is described by Haley. W. Junginger [4] made some advances in the above-mentioned problems. Anyhow, starting with the four dimensional transportation models, the application of Haley's algorithm is only theoretical, due to computational aspects. Therefore, another approach was necessary. A new and modern way of representing the multidimensional transportation problems is obtained by using the hypergraph and its characteristic matrix (Junginger [4]).

The scarcity of published work in this area indicates the low level of penetration of maritime transportation models into real industrial applications. When a ship costs millions of dollars and its daily operating costs are thousands of dollars, large profits may be expected from improving its scheduling process. Therefore, we hope that adoption of the maritime transportation models of this paper will result in significant cost savings in the operations of shipping companies.

MODELING OF MARITIME EDUCATION

To achieve a better standard of maritime education, some important measures have to be undertaken to ensure that more modern curricula are developed. Using modeling, we can improve maritime education. The method appears to be extremely efficient in planning a modern curriculum and, even more importantly, its chain structure provides an opportunity for further system development. It allows for the restructuring and modernization of existing study systems without undesirable disturbances and heavy expenditures.

According to an educational modeling chart Pudlowski [5], the proposed model starts from an existing maritime education structure and design a new system to be analyzed.

The main steps in modeling maritime education could be:
a) description of actual curriculum
b) identification of goals
c) correlation with general educational models
d) recognition of job requirements
e) development of a local curriculum, which individualises maritime education
f) development of aid curriculum (English language and computer science)
f) development of initial and continue training, prepare for life – long learning
g) according between theoretical and practical formation.

Every of the above-mentioned steps could be interpreted as a subsystem with inputs and outputs, but all of them are interdependent processes based on teaching, learning, researching. For this model the process variables are both the human resources (teachers and students) and material / information resources (equipament, computers, others aids). These resources must be harmoniously used to achieve specified educational and/or maritime objectives.

In order to test the efficiency of the model, it's necessary to experiment the practical reproduction of the model. The including activities must be easily controlled, measured and assess. On the other side, a major difficulty regarding experimental results is determining of control groups and experimental groups, taking into account the great importance of maritime work.

It is extremely important to find ways to meet the requirements of the new economy. In a rapidly changing world and a swiftly technology, ideal curricula are practical impossible to achieve. What education can do is to provide the basics and teach a methodology of self-development.

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