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   REVIEW OF LITERATURE

   NEED/IMPORTANCE OF THE STUDY

   STATEMENT OF THE PROBLEM

   OBJECTIVES

   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

   SCOPE FOR FURTHER RESEARCH

   ACKNOWLEDGMENTS

   REFERENCES

   APPENDIX/ANNEXURE

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- Bowersox, Donald J., Closs, David J., (1996), "Logistical Management." Tata McGraw, Hill, New Delhi.
- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio" Ohio State University, Nigeria.

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- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

CONFERENCE PAPERS

- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

UNPUBLISHED DISSERTATIONS AND THESES

- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

ONLINE RESOURCES

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WEBSITES

- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

PLANNING AND MANAGING A SCHEDULED SERVICE

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ABSTRACT

This paper titled planning and managing a liner vessel service is presented to deal with a common problem faced by carriers in liner shipping which is of thoughtful design of the schedule of calls to ports and proper utilization of vessel capacity for available cargo in the route by way of matching vessel capacity to available cargo in the service routes. To this purpose, computational method of selecting the number of vessels required in a fleet is presented. Factors envisaged to pose difficulties in the schedule preparation were identified as well as discussion on other shipping markets for in depth understanding of transportation system model. It is hoped that shipping companies and new entrants will find this work a great value for their shipping operations hence the inclusion of methods of determining vessel size and speed characteristics.

KEYWORDS

Planning Scheduled Service, Deliberate, Vessel Characteristics, Utilization.

INTRODUCTION

BACKGROUND INFORMATION

Ship-scheduling deals with assigning sailing times to a fleet of ships, as well as optimally the amount and type of cargo that each ship carries. Ship scheduling is a problem with significant world impact, as the majority of the world's international trade is transported by sea, so even a small improvement in schedule efficiency can have significant benefits to the shipping industry, Christainsen etal (2004).Scheduled service is a deliberate and carefully planned service decision aimed at satisfying present and future transport demands with minimum feet size. Deristieriotis (1983) is of the assertion that scheduling derives its importance from two different considerations:

(1)Inefficient scheduling results in under utilization of available resources (vessels, crews, etc.). The obvious, symptom here is the sailing of vessels with near empty capacities as a result, operating costs increase, and this reduces the competitiveness or effectiveness of the organization. (2)Poor scheduling frequently creates delays in the movement of cargoes through the route. This calls for expediting measures which again increase costs, upset previous plans, and delay other cargoes or consignments, which its late delivery results in unhappy customers Relaieva (2011).

Even though overall capacity may have been assigned to minimize the total cost from alternating periods of cargo boom (high demands) and slump (low demand), incompetent scheduling can aggregate the problem beyond any reasonable limit in terms of service costs and service levels. In all cases, the effectiveness of scheduling decisions requires adequate considerations of the interactions that exist with other decision systems responsible for forecasting demand, planning, availability of transport capacity and maintenance. The specific form of a schedule is affected by the short-term capacity provided in the overall plan and by the requirements to keep the schedule in good working order, Dervitsiotis (1981).

PROBLEM STATEMENT

Ronen (1982) in his work opined that the continuous growth of the world population and of its standard of living, combined with depletion of local resources, increases the dependence of the world economy on international trade. He emphasized that although international seaborne shipping is the major artery of international trade, relatively little research has been done in the quantitative aspect of designing and managing seaborne shipping systems. Korsvik, *et al* (2011), in their contribution further expatiated that we also see several trends like population growth, increasing standard of living, rapid industrialization, exhaustion of local resources, road congestion and elimination of trade barriers that contribute to the continuing growth in maritime transportation all compound scheduling problem and as result obviates the need for meaningful scheduling problem, Ronen (1982) noted that when a ship costs millions of dollars and its daily operating expenses are tens of thousands of dollars, large benefits may be expected from improving its scheduling process. He added that several explanations follow for the low attention drawn by ship scheduling problem:

(1) Low visibility. In the U.S.A. the minor source of research in quantitative methods, ships are a minor transportation mode: most cargo is moved by truck or rail. Moreover, numerous organizations operate fleets of trucks, but very few operate ships. Actually most of them are more dependent on ocean shipping.
(2) Ship scheduling problems are less structured than standard vehicle scheduling problems. In ship scheduling there is a much larger variety in problem structures and operating environments.
(3) In ship operation there is much more uncertainty. Ship may be delayed due to weather conditions, mechanical problems and strikes (both on board and on shore), and usually very little slack is built into their schedule, due to their high costs, Levy *et al* (1977), studied schedule performance of merchant ships, and found a probability of 0.3 of meeting a planned quarterly schedule (about 3 voyages). Thus, medium term schedules are used as guidelines and are changed very often.
(4) The shipping market is volatile, international, capital intensive and relatively free- without barriers to entry or regulation of rates. Thus, ship-owners take advantage of different national laws and regulations and therefore, capital investment decisions have a much larger effect on the bottom line than operational decision, affirmed Korsivic (2011).
(5) The ocean shipping industry has a long tradition. Ships have been around for thousands of years and therefore the industry is conservative and not open to new ideas, observed by Ronen (1982). Ronen further inferred that most quantitative models originated in vertically integrated organizations where ocean shipping is just one component of the business.

SHIP SCHEDULING BACKGROUND

Several terms must be clarified before proceeding. The term shipping in this article means moving of cargoes by ships. 'Routing' usually has a special meaning in shipping. It usually means weaker routing, i.e., closing a path in the sea between two ports of call in orderly sequences of ports of call to ships. 'Scheduling' is routing with times (or time windows) attached to the calls of the ships in the ports. Short term will mean up to several weeks forward, medium term up to several months, and long is beyond medium term.

MODES OF OPERATION

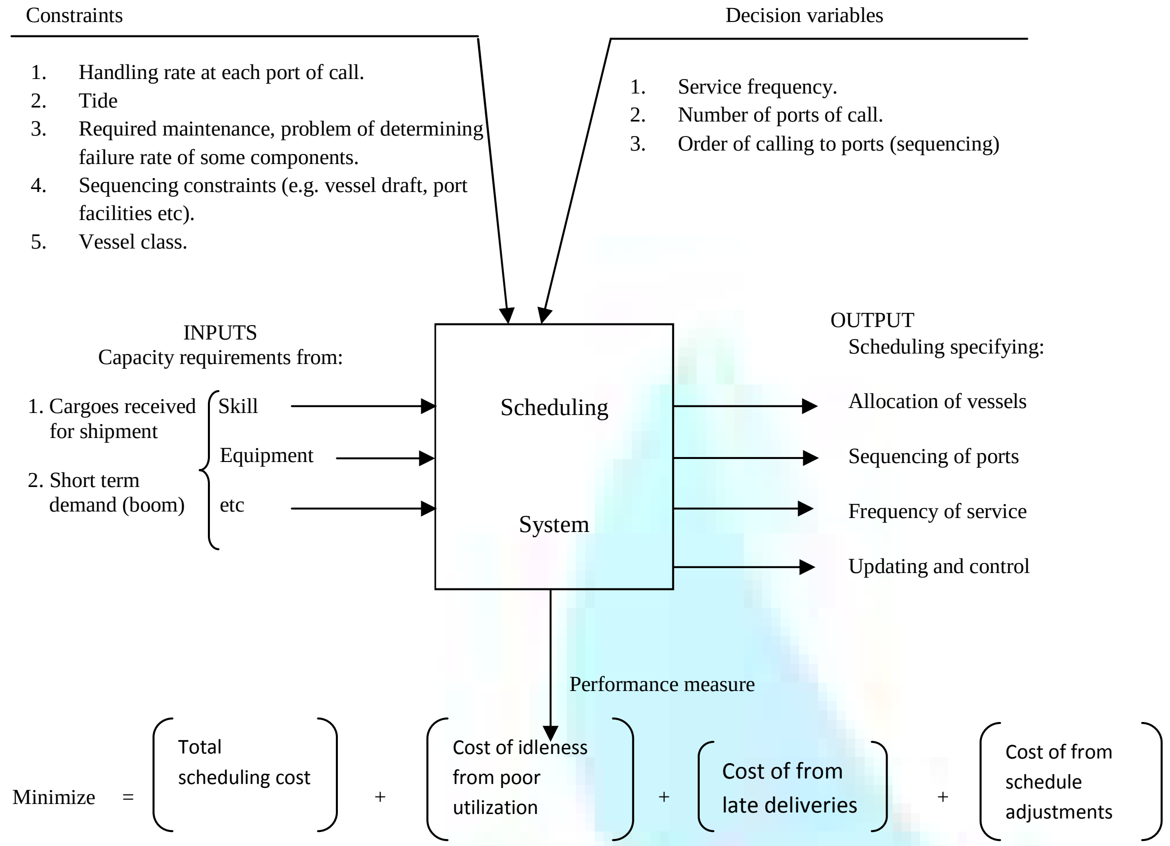
There are three general modes of operation in shipping: liner, tramp and industrial, Lawrence (1972). Ronen (1982), opined that these modes are not well defined or mutually exclusive. He explained that a ship may be easily transferred from one mode to another and an operator can operate ships in several modes at the same time. He emphasised that a liner operation resembles a busline-it publishes time tables and competes for cargo. In a further contribution Gilman *et al* (1977) made it clear that the schedule of liner ships affects the demand for their services (cargo available). Ronen (1982), is of the opinion that liners usually

operate in closed routes and often no voyage origin or destination can be defined because they may load and discharged cargo in each port of call and may never be empty. He added that a liner may be scheduled to call in a particular port more than once in a single voyage.
Tramp operation resembles a taxi-cab operation. Bausch *et al* (1998) supported this statement by emphasizing that the ships are sent where cargoes are available and usually the cargo is a whole shipload with a single origin and one or more destinations. Liner and tramp operations are common in shipping companies. Ronen is of the view that the objectives of liner and tramp operations are usually to maximize profits per time unit.
Industrial operation is similar to private truck fleet operation, Ronen (1982), but in transport parlance it is an Own-account operation. The owner of the cargo controls the fleet of ships. The ships may be owned or chartered. The primary purpose of an industrial operation is usually to assure transportation services for the organization's cargo and to reduce costs, Christiansen *et al* (2004), Ordinarily, such are sized below the organization's basic continuing requirements and fluctuations in fleet capacity needs are met by charters from other owners. Ronen still maintained that the objective of an industrial operation is usually to provide the required transportation service at minimal cost. Packard (1980), explained that ships can be chartered easily (in and out) on an international exchange, and can be bought or sold on the international market. But Bausch (1988), argued that an operator can change the size of his fleet relatively easily, adding that this process requires time.
At this point it may be informative and worthwhile to point out the major differences between standard vehicle routing and scheduling problems:
1. Ships are different from each other in their operating characteristics (capacity, speed) as well as their cost structure, Gilman *et al,* (1977).
2. The scheduling environment depends, to a large extent, on the mode of operation of the ships.
3. Ships do not necessarily return to their origin.
4. Higher uncertainty is involved in scheduling ships, (more resources of uncertainty and much longer voyages).
5. Ships are operated around the clock whereas vehicles are usually not operated during the night (except over the road, vehicles such as moving trucks). Thus ships do not have planned idle periods which absorb delays in operation.
6. Destination of ships may be changed at sea.

LINER OPERATION
Having touched extensively on scheduling problems and characteristics of vessels, we discuss liner operation. Liner operation's revenues depend on be quality of services (frequency, regularity, transit time, reliability, cheapness and so on) and therefore the availability of cargoes (revenues) depends on the routing and scheduling decisions, Faulks (2011). Ronen (1982) iterated that in liner operation, the operator's objective will be to maximize profits per time unit and not minimize costs, He added that due to the large role of uncertainty in liner operation, which stems from a relatively large number of ports of calls in a voyage and from cargo availability, the major modelling methods have been simulation and heuristic decision rules.
Datz (1968) suggested a simple calculative procedure for scheduling liners and estimating the financial results of a schedule. Neuhop (1974), gave a general discussion on the selection of ports of call for liners. Olson et al (1969), presented a deterministic simulation model used in a liner company, operating between U.S. west coast and Hawaii, for evaluating scheduling decisions. Kysland (1969) developed a more stochastic simulation model for planning purposes. His model uses linear programming in a sub-problem to determine the optimal number of ships for providing a specified service frequency. Fagerholt (2004), developed a computer-based future research. In another successful endevour, Kelareva (2011), derived the "Dynamic Under-Keel Clearance (DUKC) Optimer Ship Scheduling System, where it was emphasized that ship scheduling deals with assigning sailing times to a fleet of ships, as well as optionally the amount and type of cargo that each ship carries. Kelareva further opined that ship scheduling is a problem with significant real-world impact, as the majority of the world's international crude is transported by sea, so even a small improvement in schedule efficiency can have significant benefit to the shipping industry. Christiansen *et al* (2004), are of the opinion that one consideration in ship scheduling is that most ports have restriction on the draft of ships that are able to safely enter the ports. Draft is the distance between the water line and the ships keel, and it is a function of the amount of cargo loaded onto the ship. Ships with a deep draft risk running aground when entering or leaving the port, therefore, most ports restrict the draft developmental contribution, Almogy and Levin took a more pragmatic approach to a narrower problem. They built a stochastic model to decide what cargoes should be selected out of the available cargoes in order to maximize profit per time unit. Their objective function was linear and separable and they outlined the solution method but did not provide any example. Nemhauser and Yu (1972), discussed a model for rail service which may be applicable to liners. They used dynamic programming to find the optimal frequency of service which maximizes profit over the planning horizon when the demand for the service is a function of its frequency and timing.
Exiting work on liner scheduling by Boffey *et al* (1979) where they built an interactive computer programme, which used heuristics to schedule container ships over the North Atlantic. Their article provides a good description of a realistic ship scheduling problem environment. They used a greedy heuristic to generate schedules, but reported that managers prefer the package without the heuristic part, where schedules are generated manually and the model is a calculative one, Ronen (1982).

OBJECTIVES
To ensure a smooth service through the various ports, scheduling system must perform the following activities:
1. Loading. This involves matching the capacity requirements of cargoes or customers available (or expected) to the existing fleet size. This is accomplished by assigning vessels to specific ports, Kersvik et al (2011).
2. Sequencing: This enables the assignment of port priorities so that we can determine the sequence in which ports will be visited.
3. Dispatching: This refers to the dates the ship will sail and arrive.
4. Controlling schedule performance by:
5. Reviewing the status of demands as they operate through the route.
6. Rearranging the sequencing of ports.
7. Updating schedules. This is done as needed to reflect current operating conditions and/ or revised priorities.
8. The complexity of these tasks can be handled systematically with graphic displays or computer printouts that assist management in the evaluation and control of schedule performance.

FIGURE 1: ELEMENTS OF THE SCHEDULING SYSTEM



Source: Operations Management page 597.

FACTORS CONSIDERED IN SCHEDULING LINER VESSELS

The major restrictions on ship size for liners are port access, time spent in port and cargo availability. The increasing sophistication of cargo handling methods in the general cargo sector, and subsequent reductions in port time, have led to cargo availability being seen as the chief determinant of ship size in the liner trades. One method of easing this restriction on ship size is to widen the range from which cargo is received, and to which it is delivered. This can be done either by extensive use of support transport (either inland carriers or feeder ships) or by the use of multi-port itinerates for the main ships. Particularly in the latter ease, there is usually a trade-off between increased cargo and increased port time. In general, the shorter the route, the higher the proportion of port time, and hence the more attractive are simple itinerates of the main ships. The increase in ship size associated with shorter port time has also been accompanied in the liner trade by an overall increase in the ship speed.

Suppose a shipping company plans to enter a liner trade. How does it decide on the best ship for the route? The initial factors to be decided upon range from annual tonnage, frequency of service to be provided, to the size and the number of ships to be used.

Shorter transit times attract high paying cargoes, and competition for these cargoes results in unnecessarily high ship speeds, (Kuvas). High speed is therefore seen as marketing requirement. Service frequency, traffic demand and fleet transport capacity are the starting point in the choice for optimal ship size and speed.

Service frequency is the most likely factor independent of ship design which is given a priori in scheduling liner service. How much a restriction this is on the options for ship size and speed, number of ports, etc. will depend on the geography of the route. For a trade route such as UK-Australia, the differences in route length and voyage time associated with different choices of port will comprise a small percentage of the overall distance and time.

For a trade route such as North West Europe-U.S. East Coast, however, the sailing distance can vary between 6,500 and 11,000 miles depending on the choice of ports. Hence in the latter case there is much more variation available to the shipowner, even if service frequency is pre- determined, he still has a wide choice of combination of number of ships, voyage length, number of ports and so on. One restriction on this choice is the maximum acceptable transit time.

Service frequency and associated transit time exert a major influence not only on ship size but also on ship size. This is simply because only a limited amount of cargo can accumulate at a port during the 'service interval'. If this could be accurately quantified, the optimal size of ship would simply be that which would be full carrying all the cargoes which accumulate during this period.

In conclusion, it can be seen that service frequency is a major factor in the choice of optimal ship size and speed, but only in conjunction with other factors such as traffic demand.

TRAFFIC DEMAND

Benford suggests that ships can be divided into two distinct categories: those which are limited by physical characteristics and those limited by cargo availability. In the general cargo sector, long term contracts are less likely to be a major factor in determining trade flows, and the demand for an individual line's service will be less accurately predictable, unless the trade is a controlled one (e.g. by a strong closed conference with agreed market shares or pooling agreements as in UK-West Africa line).

Market research into individual cargo flows, competitive strength, the potential market for the ship type considered (e.g. containerisable cargoes not yet carried in containers) an external constraint question such as national legislation will therefore be required.

PREPARATION OF SCHEDULE

The preparation of a schedule is far from being an easy matter that it seems at the first glance. From the point of view of the shipowner, total scheduling and voyage costs will be minimized when a vessel loads a fill cargo at a port of origin and discharges same at a destination port and there, loads a full cargo back to port of origin or home port. Contrarily, the shippers' demand is satisfactorily met only if their consignments could be carried from wherever port they put them to which ever port/ ports they want them on the route and at the time, too. It is because of these conflicting requirements of the both parties that the shipowner should adopt a realistic schedule that will act as a compromise.

To this end, much laboriously accumulated data, much careful thought and juggling of figures, dates, and ship names go into its making. For instance in liner service from UK to West Africa, the Operations Manager of Elder Dempter Line said that "it involves the operation of ships between specified ports at approximately equal time interval, voyage after voyage, month after month the whole compilation will be determined by the length of the projected voyage, the possible frequency of sailings from the home port, the number of ports to be visited, and very importantly, the number of and characteristics of available vessels." This means that to plan a schedule, the operator will have an idea of the kind of service he would like to offer, good cargo forecast, the ports of call, the probable duration of the voyage (s) and the possible frequency of sailings. Having made up his mind on these points, he faces the fundamental decision (see figure 1) the number of ships and their characteristics (speed, class, draft, etc) which will enable him put his execution, Ryder and Chappell (1979).

Suppose a shipowner is thinking of a cargo service between United Kingdom and West African ports. He would in all probabilities, decide to put his ships into Liverpool port, London, Glasgow, Lagos - Apapa, Accra, Tema, Liberia, with stops at not more than four of the lesser ports on the West African Coast on each round voyage. He would then study the operational details of the route. This would show that to make the trip from UK Liverpool or London to Accra, Ghana and return would require 18 days although this depends on many factors among which are ship sizes, speeds, cargo availability, port time, etc., Ryder and Chappell (1979).

If the operator felt that it would be desirable to have weekly sailings from Liverpool, his fleet should be made of three ships. On the other hand, if he owned or controlled two vessels only and still wished to maintain the same itinerary, he would have to be content with a fortnightly service.

Therefore, it is clear from all the literature reviewed herein that in liner service, the schedule is basic to all plan. Renon (1982), emphasized that it determines the number of vessels required for a projected service, or, alternatively, limits the employment possible to a fleet of fixed size and capability.

Before going in detail, it will be pertinent to mention the specific factors influencing ship in operation. These are

1) Tide range which affects vessel draft and docking time.
2) Port and pilot rules of each port of call.
3) Passengers' convenience of arrival and departure (for passenger liner).
4) Longshoremen working hours and overtime rules.
5) National holidays which slow or stop operations.
6) Cargo-handling facilities for the type of cargo carried.
7) Capacity of port-avoidance of ships waiting to dock.
8) Vessel repairs-- when and where to be made.

Once the decision has been to place ships in service on a given route, the personnel of the operating department begin a systematic and detailed study of ports to be visited, the quantities and kinds of cargo to be handled in each port, and the capabilities of the ships available for this run. On routes such as the North Atlantic in winter, when the water of the ocean regularly reaches fantastic heights, it is customary to reduce speed to the average which comparable ships are able to hold under such condition, Desrosiers et al (1995).

Schedule- making personnel must have an up-to-date knowledge of the characteristics of their ships, the individual peculiarities of the cargoes normally loaded in the different ports of call, the working hairs and condition affecting the rapidity with which goods may be taken aboard or taken off the vessels, and such minor but actually very importance details as the time when pilots and tug are available to care for ships either on arrival or departure. There must also be close communication between the traffic and the operating departments, so that a plan of ship movements can be set up, based on approximately correct varieties and tonnages of cargo, Agarwal and Eryan (2010).

Christiansen et al (2004) noted that the most important factor in the line service is regularity – the dependable arrivals and departures of ships at the ports named in the schedule. To ensure this regularity, necessarily based on the most efficient use of the fleet, it may be necessary to adopt a variety of approaches: The amount of cargo accepted for a port may be limited to a quantity which can be handled in the length of time allowed for a call at the port. Thus, if a ship is to call at Port Harcourt port in Nigeria, and to stay for 14 hours and containers are handled at a rate of 15 per hour in loading and 12 per hour in discharging, the maximum that can be stowed aboard the ship is 210 containers and the maximum that could be discharged for her is 168 containers.

Alternatively, it may be decided to work a ship "around the clock" in a port, to the limit permitted by local working conditions.

The payment of overtime wages to labour may be less than the cost of holding the ship, and hence it is justified.

In planning a schedule, certain assumptions must be made at the outset of the plan. These assumptions are based on the experience of the owner and usually appear to be what can be accurately achieved by the ships. They represent the foundation on which is to be erected the structure of dependability, implicit in the definition of liner service. In the first instance, the schedule -maker assumes that the cargo liner will be loaded with a representative variety of cargo (in routes not fully containerized but in containerized routes this assumption does not hold), stowed according to the standard pattern of the line's stevedoring practice. This is determined from a study of cargo manifests for a period ranging from the last voyage. Among these is the fact of the tide range, and whether any or all of the scheduled ports can be entered when the tide is low. Should examination reveal that a port of outstanding importance (e.g. Apapa in UK – West Africa line) from the view point of cargo is accessible only at high tide, then the schedule must be adjusted to permit ships to conform to the tidal change. In London, for example, the 26-ft change in tides regularly call at London, some flexibility must be worked into their schedules so that they can fellow the prescribed time routines and still meet the advertised sailing and arrival times. This may be achieved by prescribing sea-speeds which are less than the maximum of which the ship is capable, so that the master may increase his cruising speed to arrive earlier, and thus meet the tide, or speed more rapidly after learning London and arrive at his next port approximately on the advertised time.

Alternatively, the necessary flexibility may be obtained by increasing the allowance for port time average by from 4 to 6 hours at two or three ports along the route, and leaving the execution of the schedule to the discretion of the master and advice of the ship's agents at the port by communication. No matter, however, how the planners have come to their decisions in making the schedules, port operation should be keyed to the tide, insofar as local working conditions will permit e.g., public holidays, availability of pilots in compulsory pilotage ports and the time when tugs (if necessary) are available at each port so that delays will be minimized, and the ship be made to sail with the first high tide after she finishes her cargo.

Having explained planning and managing of a schedule, it is necessary to illustrate the basic method of scheduling as follows: after investigating or surveying the route they found out that they could attain a 25–30% market share with a load factor of 0.8. This share represented an approximate monthly demand of transport capacity for 15,000 twenty equivalents units (TEUS) in a few months to perhaps 2 or 3 years. It is the kind of loan which can be expected at a given time on the operator's trade route.

The next assumption is that the ports of call and the sequence, in which they are to be visited, will not be changed during the period for which the schedule is being evolved. It is also expected that working hours and conditions of labour will not alter to any degree that would affect the efficiency of the ports. Service time at each port is rated on the number of tonnes of cargo or containers that can be handled into and out of a ship in the course of one hour, and any drop in this rate naturally will have repercussions on the schedule. Storms or unfavourable weather slow down cargo work, but unless, the ship is to sail to ports where there is reasonable assurance that such conditions will be encountered, it is customary to make allowance for the possibility of such interruptions. Underlying this custom is the unpredictability of storms and their intensity or the effects they may have on cargo operation. This, of course, is a gambler's choice, but the odds are no more unfavourable to assume good weather than bad weather when planning a schedule, Ronen (1982). Kelareva (2011) is inclined to feel that other assumptions of equal significance are that there will be no interference with the ship by reason of strikes, riots, or civil commotion, and no major breakdown of cargo- handling equipment.

I can add that these assumptions, based on the historical experience of the company planning the schedule, reflect the actual conditions which have been encountered in the past, and the performance records of the ships employed in the trade for which the schedule is being developed, more especially the respective speed of the ships in the fleet. If the planners of the schedule or the ship operator have had no personal experience in the service, for which the schedule is being drawn up, it is essential that he obtains all possible pertinent information from steamship agents, consultants, and/or his own operating personnel who may have made detailed surveys of port conditions. Moreover, volume of trade will be forecast for the rate.

On the basis of these assumptions, it becomes possible for the operating department to consider the specific factors which will influence the schedule.
The company found out from shippers that a weekly service would be satisfactory to their demand. The number of ports of call for each ship was decided, plus some feeder service ports. The company decided the size and speed characteristics and number of ships required for this service thus:

15 – 30% market share approximately 15,000 TEUs (monthly)

Weekly service $= \frac{1500}{4}$ = 3,750 TEUs /week.

Ship size at 0.8 load factor $= \frac{3750}{0.8}$ ≈ 4,600 TEUs

Past experience shows that 1 day port time is reasonable and they decided to call to 24 ports on the route giving port time = 24x1day = 24 days.
Roundtrip distance is approximated to 40,000 nautical miles.
Speed of the vessel is planned to be 18knots
Sea voyage time plus port time = round trip time $= 24 + \frac{4000}{18 \times 24}$ = 116.59 day
= 177 days approx.

- Number of ships required to maintain weekly frequency

$= \frac{177}{0\ 7}$ = 16.7 ≈ 17 ships.

Having determined the fleet size of the company, the selected speed considered ideal for the voyage and forecast load factor, the schedule can be prepared to enter the new route. The schedule must be updated and maintained in response to periodical trends in the shipping environment.

SUMMARY

Ship scheduling problems are varied and complex- The high uncertainty associated with ship operation confines the applicability of deterministic models to long and medium term planning. So medium term schedules are used as guidelines and must be updated often. Actual scheduling is done with the fleet and cargoes available for loading at the moment. The recent trend toward computerized interactive scheduling systems, which are used mainly to evaluate alternative schedules, demonstrates the complexity of the problem and limited applicability of existing mathematical programming models to operational ship schedules.
In a search, only a few models or computerized systems, for short terms scheduling were found. Essentially, the short term scheduling problem boils down to three questions: where are empty ships sent? where are loaded ships sent? and what cargoes to load on what ships? The answers to these questions may change frequently with changes in the fleet operating environment. The relation between the medium term schedule (the plan) and short term problem (the execution of that plan) is blurred by the operational uncertainty which is usually not accounted for in the medium term plan. This relation, which is complicated by binary aspect of scheduling problems (is the specific ship at the right place at the planned time, or not?) is not well understood and requires further analysis.
The objective of scheduling is not always clear cut especially in tramp shipping where not all cargoes available are known in advance. Liner operations try to maximize profit per time unit in the long run but may divert from this objective in the short run in order to gain market share. Industrial operations try to minimize cost as long as they are engaged in intra-corporate service, but once they look for backhauls for other parties they face problems similar to tramp shipping. When cost minimization is the objective, all relevant cost components should be taken into account, including port entry charge, cost of loading and discharge times and demurrage.
The ship scheduling problem becomes more realistic when two additional decision variables are considered: the cruising speed, and the shipment sizes. The fuel consumption of a motor ship, which may cost tens of thousands of dollars a day depends on the third power of its speed and is a major component of operating cost. Thus the cruising speed should be considered when a schedule is determined. Shipment sizes may often vary in a given range, especially in industrial operations and such variations allow larger flexibility for the human schedulers than for a mathematical model which does not account for them. A further realistic aspect may be instilled by trying to avoid ports on weekends and public holidays, when cargo handlings do not take place.
Fleet routing and scheduling problems cannot be disconnected from fleet size and mix decision since the latter imposes constraint on the former, at least in the short run.
Most of the publications in ship routing and scheduling have been performed in industrial operation and very little has been done in other areas. Even in industrial operations, the existing models are realistic aspects of ship scheduling problems. When a ship costs tens of thousands of dollars a day, large cost savings can be realized by proper scheduling of a fleet, but realistic models are needed to achieve those savings. Hence it is highly recommended that more serious research be conducted in this same area of shipping operations management.

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